STUDY OF RISK FACTORS AND OUTCOME IN EXTERNAL VENTRICULAR DRAIN INFECTIONS

A THESIS SUBMITTED TO BABA FARID UNIVERSITY OF

HEALTH SCIENCES, FARIDKOT (PUNJAB)

IN THE PARTIAL FULFILLMENT

FOR THE AWARD OF DEGREE OF

MCh

IN

NEURO-SURGERY

MAY, 2023

Submitted By

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Dedicated

to

my Family

&

Teachers

ACKNOWLEDGEMENT

I feel an upsurge of pride and satisfaction to express my sincere and deep gratitude to my esteemed teacher and elite supervisor ***Dr. Ashwani Kumar Chaudhary,*** *Professor and Head, Department of Neurosurgery, Dayanand Medical College and Hospital, Ludhiana for imparting precious and invaluable guidance throughout this work. It is the matter of great honour that Almighty has bestowed upon me an opportunity to learn and work under stewardship and leadership of a stalwart. His truly scientific approach has made him as a constant oasis of ideas and passion, which has exceptionally inspired and enriched my growth as a student of Neurosurgery. As a hard task master he is always on the mission to infuse in his students and juniors the sense of compassion, duty and perseverance to relieve sufferings of the sick with apt knowledge and high quality services. His such missionary qualities have left a deep imprint on my mind and I have honour to study under his able guidance.*

I offer thanks from core of my heart to esteemed co- supervisor ***Dr. Shivender Sobti****, Professor, Department of Neurosurgery, Dayanand Medical College and Hospital, Ludhiana for his visionary and valuable guidance throughout the course of study. He has been a pioneer force in clearing bottle necks faced during this work. In his capacity of such a great responsibility which he has been discharging, he has acquitted himself with great success, honour, reputation of top class healer and succour, while endearing himself to medical fraternity. He made all out efforts for imparting invaluable guidance without which this work would not have seen light of the day.*

Words cannot express my indebtedness to ***Dr. Hanish Bansal,*** *Associate Professor, Department of Neurosurgery, Dayanand Medical College and Hospital, Ludhiana for his guidance, undying patience, priceless suggestions, timely help and ever flowing encouragement for accomplishment of this work. I perceive him as an erudite counsellor and strict disciplinarian. I will always remain thankful for his whole hearted support throughout.*

My special gratitude to ***Dr. Jagminder Singh,*** *Assistant Professor, Department of Neurosurgery, Dayanand Medical College and Hospital, Ludhiana for his persistent encouragement. His constant suggestions and critical evaluation has helped me a lot to sail the boat of my dissertation to destination.*

I thank profusely to ***Dr. Saurabh Sharma,*** *Assistant Professor Department of Neurosurgery Dayanand Medical College and Hospital for motivating and instilling enthusiasm in me to render myself in quest of knowledge. His inspiration,*

timely suggestions with kindness and dynamism has boosted me to accomplish this task.

I am immensely fortunate to gratefully acknowledge the support of my sister ***Dr. Cherry Walia*** *for her unconditional help. Her valuable suggestions have prevented several wrong turns during this endeavour. I am blessed to have sibling like her.*

I am extremely grateful to my parents ***Mr.Pardeep Singh Walia*** *and* ***Mrs.Raghbir Kaur*** *for their prayers, caring and sacrifice for educating and preparing me for my future. They are images of God on earth for me. Their unconditional love and support has meant the world to me.*

I would like to express my deepest appreciation to my spouse ***Dr. Tejinder Kaur Walia,*** *who stood with me through all my travails, thick and thin. She handled and settled multiple day to day chores at her own providing me hassle free time to carry on my mission. I owe to her a lot. I append my sincere love to my children* ***Ruhin*** *and* ***Gurnaaz****. Their affection and smiling faces have always invaded my inner torrents and propelled me to rise above afflictions and remain in high spirits.*

It gives me great sense of pride to admire the contribution of my brotherly friend ***Dr. Harpreet Momi****. He is not only my true well wisher but also my ardent supporter forever.*

I am highly obliged to my companion of this Journey, ***Dr. Swarjith Nimmakayala*** *for always being a helping hand. His understanding nature has nurtured a positive atmosphere in which we strived together to chase our dreams.*

My special thanks to my seniors ***Dr. Tarun Garg, Dr. Manish Sharma*** *and my colleagues* ***Dr. Saurav Mittal, Dr. Atul Jadhav, Dr. Vaibhav Lakhanpal*** *and* ***Dr. Prabhat Purohit*** *for their precious advices. Their proposals have paved the way for resolution of many problems. I also thank* ***Mrs. Namita Bansal*** *and* ***Mr. Tarun Sharma*** *for their help in compiling this thesis.*

This acknowledgment will be incomplete without mentioning the role of nursing and assistance staff attached with Department of Neurosurgery, DMC&H, Ludhiana. Their help has been invaluable throughout my voyage.

Above all, I am grateful to all the patients whose cooperation was of paramount importance for this study, without whom this study would not have been possible.

Dr. Ramandeep Singh Walia

LIST OF ABBREVIATIONS

CNS	Central Nervous System
CSF	Cerebrospinal Fluid
DD	Drainage Days
ERI	EVD related infections
EVD	External Ventricular Drain
GCS	Glassgow Coma Scale
GOS	Glassgow Outcome Scale
ICU	Intensive Care Unit
KOH	Potassium Hydroxide
LD	Lumbar Drain
RCT	Randomised Control Trial
VAI	Ventriculostomy associated infections
ZN	Ziehl Neelsen

KEY TO MASTER CHART

ACA:	Anterior Cerebral Artery
ACOM:	Anterior Communicating Artery
EVD:	External Ventricular Drain
GCS:	Glassgow Coma Scale
GOS:	Glassgow Outcome Scale
ICH:	Intracranial Hemorrhage
IVH:	Intraventricular Hemorrhage
KOH:	Potassium Hydroxide
LRTI:	Lower Respiratory tract infections
MCA:	Middle Cerebral Artery
SAH:	Subarachnoid Hemorrhage
ZN:	Ziehl Neelsen

ABSTRACT

Introduction: External Ventricular drains are used for monitoring the intracranial pressure as well as therapeutically for diverting the cerebrospinal fluid from obstructed ventricular system. However, it is associated with many complications and the most common complication is EVD infection.

Aims and Objective: To analyse the risk factors and the outcome in patients with external ventricular drain related infections.

Materials and Methods: In our study, 66 patients admitted to the Neurosurgery ICU of Dayanand Medical College and Hospital for EVD placement from August 2021 to October 2022 and following the inclusion criteria of the study were included in the study. The data collected was compiled and analysed to study the incidence, risk factors and the outcome of the external ventricular drain infections.

Results: Out of 66 patients who were enrolled for the study, 5 patients developed EVD infections giving an incidence of 7.6% of EVD infections. Prolonged duration of EVD drainage, frequency of CSF sampling and systemic coinfection were the risk factors found to be significantly associated with EVD infections. Patients with EVD infections were having longer hospital stay however it doesnot significantly affect the Glassgow outcome scale at the time of discharge.

Conclusion: Our study demonstrated prolonged duration of EVD infections, frequency of CSF sampling and systemic coinfection as significant risk factors of EVD infections so widespread attention should be given to these factors to reduce the incidence of EVD infections.

Keywords: External Ventricular Drain, Infection, Risk factors, Outcome

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INTRODUCTION

External Ventricular drains are used for monitoring the intracranial pressure as well as therapeutically for diverting the cerebrospinal fluid from obstructed ventricular system.[1] External ventricular drain insertion is the life saving treatment in neurosurgical intensive care patients. It helps in preventing damage to the brain parenchyma due to raised intracranial pressure.

The cerebrospinal fluid is secreted in the ventricles of brain by the choroid plexus and it circulates in the subarachnoid space of the brain and spinal cord. It then get absorbed within the arachnoid granulations in to the venous system. The daily CSF production is approximately 0.2-0.4 ml/min.[2,3] Normally equilibrium exists between the production and absorption on cerebrospinal fluid. However, certain conditions e.g traumatic brain injury, intracranial hemorrhage with intraventricular extension, meningitis, subarachnoid hemorrhage can disturb this equilibrium leading to raised intracranial tension.[4] Increase in intracranial pressure can lead to reduced cerebral perfusion which can exacerbrate cerebral ischemia and secondary brain injury. Compression, distortion and herniation of brain tissue can lead to death.[5-7]

Thus Indications of External Ventricular Drainage includes:[8,9]

1) Meningitis induced hydrocephalus.
2) Hydrocephalus associated with Sub Arachnoid Haemorrhage
3) Intraventricular Haemorrhage and Ventricular extension of Supratentorial ICH
4) Infratentorial ICH and posterior fossa infarct
5) Post traumatic hydrocephalus
6) Space Occupying Lesions causing hydrocephalus
7) Malfunctioning Ventriculoperitoneal shunt
8) Monitoring Intracranial pressure in critically ill patients

Insertion of external ventricular drain in these conditions can lead to reduction in intracranial tension by diverting the cerebrospinal fluid and intraventricular blood.

EVD is inserted by either burr hole or twist drill technique. Kocher's point is the most common choice for EVD placement. The Kocher's point is located 11 cm posterior to the nasion in adults; equivalent to 1 cm anterior to the coronal suture, and 2 to 3 cm lateral to the midline, which is equivalent to the mid-pupillary line .Then the catheter follows a trajectory aiming towards the ipsilateral medial epicanthus at the coronal plane and ipsilateral external auditory meatus at the sagittal plane. The catheter tip should be 5-6 cm from the inner table of calvarium, inserted in frontal horn of lateral ventricle or anterior to foramen of Monro.[10-12]

Points of ventricular puncture include[11]:

1. Keen's point: -2.5 to 3 cm posterior and 2.5 to 3 cm above the pinna of the ear
2. Kocher's point: This point is 1 to 2 cm anterior to the coronal suture in the mid pupillary line, or 11 cm posterior from the glabella and 3 to 4 cm lateral from midline ipsilateral medial canthus and a line extending coronally from the ipsilateral tragus
3. Dandy's point: 3 cm above and 2 cm lateral to the inion
4. Frazier's point: 6 cm above and 4 cm lateral to the inion
5. Paine's point- the apex of an isosceles triangle, whose base is 3.5 cm and lies along the Sylvian's veins, and each of the two limbs is 2.5 cm.
6. Tubbs' point- a point just medial to the midpupillary point through the roof of the orbit - the trajectory aims 45 degrees from a horizontal line and 15 to 20 degrees medial to a vertical line.

The accuracy of EVD insertion can be further improved by ultrasonogram, neuronavigation and by adjustable Ghajar guide technique.[13]

Kakarla introduced the grading system of catheter placement depending upon the position of catheter.[14]

- Grade 1 (optimal)-ipsilateral frontal horn, including the tip of the third ventricle
- Grade 2 (suboptimal and in the non-eloquent area)-contralateral frontal horn, corpus callosum, or interhemispheric fissure
- Grade 3 (suboptimal and in the eloquent area)-basal ganglia, internal capsule, thalamus, brainstem, cerebellum, basal cisterns, and occipital cortex

EVD insertion is associated with many complications which includes intracranial or tract hemorrhage, vascular injury, CSF leak, pneumocephalus, accidental pull or fracture ,blockage due to kinks or obstruction, excesive drainage leading to aneurysmal rebleed, obstruction by choroid plexus and infection. Infection is the most common complication of EVD .[8] The rate of EVD related infections ranges from 5 to 23% with average close to 10%.[15] EVD infections prolongs the hospital stay of patient and also increases the financial burden on the patient and hospital. It is also associated with significant morbidity and mortality.[16] Different conditions have been found to increase the risk of infection in EVD patients. These include patients with subarachnoid hemorrhage or intraventricular hemorrhage, CSF leak, frequent CSF sampling (each sampling increases the risk of infection by 8 %),catheter irrigation, frequent changing of catheter (each change in catheter increases the risk by 4 fold), prolonged duration of catheter insertion(9.3 % risk with duration of >-8 days),concurrent systemic infections, depressed skull fracture.[17-21]

However, no difference was observed in terms of place of EVD placement i:e whether EVD was inserted in operating room or at bed side. Experience of the operating surgeon and anatomical point of insertion also don't alter the risk of infection. [17,22,23]

Use of antibiotic impregnated catheters reduces the risk of infection by 20%. The commonly used antibiotic impregnated catheter contain

clindamycin and rifampicin while silver impregnated catheters contain silver nano particles. These antibiotic impregnated catheters prevent and kill bacteria, thus reducing the risk of EVD infections. Bolt EVD reduces the risk of CSF leakage and tube migration.[17,24]

Infection can be introduced either during the surgery, routine care of the drain, or retrogradely from the distal end of the drain.[1] Retrograde spread from the distal end of drain is the most common route of EVD infections.[25]

The commonly found pathogens in EVD infections are skin commensals e:g Gram positive coagulase negative staphylococci, Staphyl ococcus aureus, and Gram-negatives Escherichia coli, Acinetobacter spp., and Klebsiella spp .[26]

Diagnosing EVD infections is a great challenge as the symptoms of infection can be masked by the primary neurosurgical condition, in patients with blood admixed with CSF obscuring CSF characteristics of infection or sterile inflammatory response secondary to surgical intervention. These diagnostic dilemmas lead to delay in diagnosing and treatment of EVD infections.[27]

According to the Center for Diseases Control and Prevention, the criteria for ventriculitis or meningitis diagnosis are as follow: (1) positive CSF culture results plus clinical symptoms or CNS pleocytosis/cell count increase; or (2) in the case of negative CSF culture, clinical symptoms and increased pleocytosis of the central nervous system (CNS), increased serial measurement/cell count, hypoglycemia (less than 50% of simultaneous blood sugar), and increased lactate (more than 2 mmol/dL or 36 mg/lit) or gram-positive smear.[28] Thus, whenever a external ventricular drain infection is suspected, a sample of CSF is taken from drain and is sent for gram staining, Potassium hydroxide (KOH) stain, Ziehl Neelsen (ZN) staining, culture, concentration of glucose and ratio, leukocyte count and differentiation and total protein concentration.[28-30]

EVD infections increases the length of hospital stay of the patients and impose financial burden on patient family. It increases the morbidity and mortality of the patients. Thus, timely diagnosis and management of the patient can help in improving the outcome.

Incomplete knowledge of factors which lead to external ventricular drain infections has led to poorly standardised EVD prevention strategies. In the last 20 years, the focus is on improving the accuracy of access to the ventricles, control of infections and the safety of procedure. Thus, the study was conducted to have better knowledge of various risk factors of external ventricular drainage devices related infections and their outcomes so that preventive measures can be taken to prevent this complication.

AIMS AND OBJECTIVES

1. To analyse the risk factors associated with external ventricular drain related infections.
2. To assess the outcome in patients of external ventricular drain related infections.

REVIEW OF LITERATURE

The cerebrospinal fluid was first documented as fluid in brain by The Edwin Smith Surgical Papyrus and as pathological "moistness" by Hippocrates. It was described as excretionary liquid for "pneumas" (spirit) by Galen and Swedenborg called it as spirituous lymph". In year 1825 Magendie, called it as "liquid cephalo-spinal".[31,32]

The external ventricular drainage was first described in 18th century by Claude-Nicholas Le Cat for treating the patients of congenital hydrocephalus. He described the procedure as puncturing the ventricles with catheter and trocar.[33] The mid 19th century observed advancements in external ventricular drainage system by adoption of aseptic technique, optimal sites of catheter insertion and with the knowledge of consequences of excessive drainage. In 1941 Ingraham and Campbell described the first sterile closed ventricular drainage system .the stopcock in the system allow slow and controlled CSF drainage to prevent excessive CSF drainage.[34,35] further advancements in EVD included introductions of drip chamber to prevent retrograde flow of CSF and use of silicone catheters for subcutaneous tunneling.[36,37] The increased safety of EVD increases the indications for EVD insertion. Ventricular pressure monitoring and drainage introduced by Franklin Robinson in 1948 increases the use of EVD in non traumatic conditions like brain tumors, subarachnoid hemorrhage, cerebral edema due to Reye's syndrome.[34,37,38]

However, External ventricular drainage device are associated with many complications with infection being the most common complication reported in the literature. EVD infection can be complicated by ventriculitis, meningitis, subdural empyemas or brain abscess which are the dreadly complications.

In a prospective epidemiological study to study the incidence, risk factors and clinical characteristics of ventriculostomy related infections on 172 patients over 2 years period, Ventriculitis occurred in 19 patients (11 %)

out of 172. Cerebrospinal-fluid pleocytosis was more significantly associated with the diagnosis of ventriculitis or meningitis (P less than 0.0001) than were fever and leukocytosis (P = 0.07). Risk factors for ventriculitis were found to be intracerebral hemorrhage with intraventricular hemorrhage (P = 0.027), neurosurgical operations (P = 0.016), intracranial pressure of 20 mm Hg or more (P = 0.019), ventricular catheterization for more than five days (P = 0.017), and irrigation of the system (P = 0.021). No increased risk of infection was found on subsequent procedures in patients with previous ventriculostomy in this study. The study concluded that ventriculitis may be prevented by maintaining closed drainage system and by early removal of the ventricular catheter. The catheter should be removed and inserted at a different site if monitoring is required for more than 5 days.[39]

In another study conducted on 78 patients to study the rate of bacterial ventriculitis in relation to duration of catheter insertion and the factors which contribute to drain infections, it was found that higher rate of ventriculitis was found in patients with mean catheter duration of 11 days or more than that. It was also found the group which developed the ventriculitis showed increase in cerebrospinal fluid lactate levels prior to the onset of ventriculitis.[28]

In a prospective surveillance study conducted to determine drain associated infection rates and Drainage Days(DD) of hospital acquired external ventricular drain (EVD) and lumbar drain (LD) associated meningitis/ventriculitis in a neurosurgery and a neurological intensive care unit,1333 patients were included, amounting to 3023 DD. 26 cases of meningitis were reported after excluding 15 cases of contamination, accounting for an overall device associated meningitis rate of 8.6 infections/1000 DD. Infections associated with Lumbar Drain seemed to occur more frequently (19.9/1000 DD) compared with EVD (6.3/1000 DD). The presence of intraventricular blood and previous trauma were significant risk factors for infection (p=0.003; p=0.04). The length of stay

was significantly longer in meningitis patients (p=0.0003). Coagulase negative staphylococci were the main pathogen (56%) causing meningitis, followed by Staphylococcus aureus (25%).[29]

Another study conducted to analyse external ventricular drainage related ventriculits, 174 EVD catheters were introduced in 112 patients. 15 patients developed ventriculitis presenting infection incidence rate of 13.39% per patient and 8.62% per procedure. Out of 15 patients, 5 patients died from sepsis, 7 patients recovered from infections but some neurological complications were seen and 3 patients recovered without any complications. The most common pathogen found in this study was Acinetobactoer baumanii. The prior clinical diagnosis showed the statistical significance as a risk factor. Higher incidence of infection was seen in patients with severe head trauma because of contaminative environment.[40]

In another study conducted on 228 patients from January 1993 to April 2005, the most common indication for External ventricular drain placement was hydrocephalus due to intraventricular haemorrhage (48.2%). Ventriculitis occurred in 23.2% of all patients. The duration of EVD drainage was found to be a risk factor for infection (>11 days: OR 4.1; 95% CI 1.8-9.2, p = 0.001). Another risk factor was the frequency of CSF sampling (no sampling: OR 0.2, 95% CI 0.2-0.5, p = 0.003).[41]

In a study conducted in Brazil to study the incidence rates and risk factors predisposing ventricular device procedures and 839 catheter days were evaluated. The infection incidence was found to be 18.3%, 16.9% per procedure was the infection rate and the drain associated infection rate was 22.4 per 1,000 catheter days. 77% of infection were caused by Gram negative organisms. 75% patients received antibiotic prophylaxis. The rate of infection increases with the longer hospital stay of the patients. The duration of time catheter was in place was found to be independent risk factor associated with infection.[42]

In a retrospective study conducted on 199 patients to evaluate the relationship among duration and revision of external ventricular drain and cerebrospinal fluid infections, 269 external ventricular drain were inserted at a major trauma centre in Australasia. Out of total 21 cerebrospinal fluid infections, 10 (48%) were found to be caused by Acinetobacter. Multiple insertions of external ventricular drains were found to be a significant risk factor. In previously uninfected patients second and third external ventricular drain was found to be more likely associated with the infection rate. The mean period of external ventricular drain was found to be 5.5$\pm$0.7 days postinsertion. [43]

In another retrospective study conducted on 343 patients who underwent External Ventricular drain placement, 12 patients acquired infection. No significant difference was found in patients with or without ventriculitis for age, sex and underlying systemic infections. Concomitant systemic infections was seen in 4.7% of patients with External ventricular drain related infections compared to 1.5 % patients without external ventricular drain related infections. The difference in length of EVD placement in patients with ventriculitis was 20.9 ± 15.3 days and 12.1 ± 18.2; P = 0.005 in patients without ventriculitis and difference was found to be significant. The most commonly associated pathogens were Coagulase-negative Staphylococcus and Staphylococcus aureus.[21]

In a retrospective single centre study conducted on 218 patients with 246 EVD placement over a 30 month period to evaluate the incidence of external ventricular drain related infections and to identify the underlying risk factors, the cumulative incidence of infection was found to be 8.3%(95% CI, 5.3-12.7) with device associated infection rate of 10.4 per 1000 drainage days (95%CI, 6.2-16.5). Patients with EVD related infection had a longer stay in intensive care unit (11 versus 21 days,P <0.01) and in hospitals (20 versus 28.5 days, P<0.01) than patient without infections. The mean total duration of external ventricular drain was twice longer in patients with external ventricular drain related infections (6 versus 12

days, P<0.01). The most common pathogen found was coagulase negative Staphylococcus (62%) followed by Enterococcus spp (19%). There was no significant difference in the duration of first External ventricular drain placement and the occurrence of infection and external ventricular drain removal in patients without ventriculitis (6 versus 7 days, P=0.87) respectively.[44]

In a retrospective study conducted at Aga khan university hospital to study outcome of external ventricular drain infections and predictors of unfavourable outcome, 256 patients were included. 66 patients (25.8%) developed VAI. EVD was the primary procedure in 21 (31.8%) cases. 24 (36.4%), had EVD as a secondary procedure for tumor surgery. Median interval between EVD placement and diagnosis of infection was 3 days. Mean length of stay in VAI patients was 31.85 ± 20.53 days. Seven patients required ICU care. Ten patients (15.2%) expired during hospital stay or within 30 days of discharge and further four had GOS of 2 or 3. A total of 52 patients had a favorable outcome after 6 months. The study concluded that ventriculostomy infections were associated with increased morbidity, increased mortality and prolonged hospital stay.[45]

In another study conducted on 58 patients undergoing External ventricular drain insertion in the Intensive Care Unit (ICU) in Neurosurgery Department of Xuanwu Hospital of Capital Medical University between January 1 and December 31, 2015, the infection rate was calculated as 8.6% (10.9/1000 EVD days). The duration of EVD (≥11 d, Wals=4.8, RR=17.3, 95% CI: 1.4-218.3, P=0.028), CSF sampling frequency (≤2 d, Wals=5.3, RR=15.3, 95% CI: 1.5-243.7, P=0.022), and concomitant pulmonary infection (RR=7.8, 95% CI: 0.8-74.8, P=0.04) were found to be the risk factors of EVD-related infections.[46]

In a survey conducted in subspecialty hospital in Tehran (Iran) on patients with an external ventricular drain (EVDs) from Jun 23, 2018, to Jun 23, 2019, Patients are monitored within 30 days of EVDs placement for infection. Data on demographic information, underlying diseases,

number of EVD replacements, length of hospital stay, type consumed antibiotic before neurosurgery, length of tunneling, type of airway, duration of mechanical ventilation, duration of surgery (hours), surgeon name, APACHE II score, length of intensive care unit stay are collected. The diagnosis was based on the Center for Diseases Control and Prevention criteria for meningitis/ventriculitis and clinical vision of infectious or critical care specialists. Out Of 81 patients with EVDs, 39 (48.1%) were infected. The mean age of patients was 44.33+_19.5 years, and 55.6% of them were male. According to the multiple logistic regression analysis, mechanical ventilation for more than 6 days (OR: 2.5, 95% CI: 1.6 - 3.56, P = 0.04) and length of tunneling> 5cm(OR: 1.98, 95%CI: 1.87 - 4.76, P = 0.02) were identified as factors that could predict EVD infection. Also, consuming ceftazidime + vancomycin, as a prophylaxis agent, had a lower odds ratio for EVD infection (OR:0.4, 95% CI: 0.08 -0.84, P = 0.04).[30]

In a prospective multi centre cohort study to study the infection rate and risk factors for external ventricular drain infections in 21 neurosurgical units over 6 months, a total of 495 EVD catheters were inserted into 452 patients with EVDs remaining in situ for 4700 days (median 8 days; IQR 4–13). Of the catheters inserted, 188 (38%) were antibiotic-impregnated, 161 (32.5%) were plain and 146 (29.5%) were silver-bearing. A total of 46 external ventricular infections occurred giving an infection risk of 9.3%. Cox regression analysis demonstrated that factors independently associated with increased infection risk included duration of EVD placement for ≥8 days (HR=2.47 (1.12–5.45); p=0.03), regular sampling (daily sampling (HR=4.73 (1.28–17.42), p=0.02) and alternate day sampling (HR=5.28 (2.25–12.38); p<0.01). The study concluded that External Ventricular Drains left in situ for ≥8 days and frequent sampling of cerebrospinal fluid were associated with a higher risk of infection.[20]

In a study conducted in single 440-bed academic medical center reviewing all EVD associated infections between January 2014 and October 2018 to compare the rates of EVD-AI before and after application

of the Infection prevention bundle. The study measured different variables including procedure time, EVD placement location & duration, cerebrospinal fluid (CSF) specimen source, surgeon, and the presence of EVD-AI. Out of 105 eligible patents, Seventy patients had CSF analysis performed; 37 had possible EVD-AIs (31 pre-IPB and 6 post-IPB) and 7 were confirmed EVD-AIs (5 pre-IPB and 2 post-IPB) with no statistically significant difference pre- and post-IPB. The EVD duration (OR 1.20), EVD placement procedure (OR 2.38), and CSF specimen source (OR 7.00) were associated with increased risk of infection. The study identified longer EVD duration, EVDs placed at bedsides, and CSF drawn from EVD collection bags as the risk factors for EVD associated infections.[47]

In a study conducted to identify the risk factors for EVD infections in institution from March 2015 to May 2019, 479 EVDs placed in 409 patients met inclusion criteria, and 9 culture-positive infections were observed during the study period. The risk of infection within 30 days of EVD placement was 2.2% (2.3 infections/1,000 EVD days). Coagulase-negative staphylococci were identified in 6 of the 9 EVD infections). EVD infection led to prolonged length of stay post–EVD-placement (23 days vs 16 days; P = .045). Cox regression demonstrated increased infection risk in patients with prior brain surgery associated with cerebrospinal fluid (CSF) diversion (HR, 8.08; 95% CI, 1.7–39.4; P = .010), CSF leak around the catheter (HR, 21.0; 95% CI, 7.0–145.1; P = .0007), and insertion site dehiscence (HR, 7.53; 95% CI, 1.04–37.1; P = .0407). Duration of EVD use >7 days was not associated with infection risk (HR, 0.62; 95% CI, 0.07–5.45; P = .669). The study identified prior brain surgery, CSF leak, and insertion site dehiscence as possible risk factors for EVD infections.[48]

MATERIALS AND METHODS

The study was conducted on patients who underwent external ventricular drain placement in Department of Neurosurgery in Dayanand Medical College and Hospital, Ludhiana from August 2021 to October 2022. The study was approved by thesis and ethical committee of the institution.

Inclusion criteria

1. All the patients above the age of 18 years who underwent EVD placement.

Exclusion criteria

1.Patients with previous history of Central nervous system infections.

2.Patients presenting with open skull fracture.

3.Patients presenting with Cerebrospinal fluid leakage.

The data was collected according to the demography, clinical diagnosis of the patient, previous medical history of any disease, previous history of placement of external ventricular drain, duration of EVD (in days), total number of EVD per person, frequency of cerebrospinal fluid sampling, microbiological result and the clinical outcome.

OPERATIVE PROCEDURE

The SURGIWEAR external ventricular drain was used in the study and it was inserted under sterile conditions in the operation theatre. The patient's scalp was shaved and prepared with standard sterile technique. The skin incision was given at kocher's point and catheter was inserted in to the frontal horn of the ventricle for about 5 cm until cerebrospinal fluid was obtained. The catheter was then tunneled under scalp laterally for about 5cm and was connected using 3 way stopcocks to external cerebrospinal drainage system. The catheter was securely fixed with suture and sterile dressing was applied. None of the catheters were impregnated with antibiotics. Prophylactics antibiotics was administered before catheter insertion and during the period of drain in place.

All the patients were monitored in intensive care unit and dressing was done daily. The elevation of catheter was forbidden to prevent back flow of cerebrospinal fluid.

The sample of cerebrospinal fluid was taken at the time of external ventricular drain insertion and on 4^{th} day, 7^{th} day, 10^{th} day or when patient developed signs of sepsis. The cerebrospinal fluid was sent for cytology, biochemistry study, gram staining, KOH stain, ZN staining and culture. The blood sample was taken at the time of cerebrospinal fluid sampling for monitoring blood glucose levels.

Criteria for diagnosis of EVD infections- According to the Center for Diseases Control and Prevention, the criteria for ventriculitis or meningitis diagnosis are as follow: (1) positive CSF culture results plus clinical symptoms or CNS pleocytosis/cell count increase; or (2) in the case of negative CSF culture, clinical symptoms and increased pleocytosis of the central nervous system (CNS), increased serial measurement/cell count, hypoglycemia (less than 50% of simultaneous blood sugar), and increased lactate (more than 2 mmol/dL or 36 mg/lit) or gram-positive smear.[12] Thus, whenever a external ventricular drain infection is suspected, a sample of CSF is taken from drain and is sent for gram staining, Potassium hydroxide (KOH) stain, Ziehl Neelsen(ZN) staining, culture, concentration of glucose and ratio, leukocyte count and differentiation and total protein concentration.

If a patient was found to have external ventricular drain related infection, then more detailed findings were taken with regard to the possible factor leading to infection, antimicrobial susceptibility, treatment provided and the outcome of the patient.

If a patient required external drain insertion for extended duration then a new external drain was inserted at another site at 10^{th} day.

If the cerebrospinal fluid culture study shows positive result, the antibiotic therapy was started based on culture studies.

Outcome

Morbidity of the patients was assessed and the patients were grouped as good recovery, moderate disability, severe disability and vegetative state, death on the basis of criteria laid down by Glasgow Outcome Scale.

Statistical Analysis

Data on demographic information (age and sex), diagnosis, number of EVD placements, length of ICU stay and hospital stay, laboratory tests i:e serum and CSF analysis were also recorded. Data were described in terms of range; mean ±standard deviation (± SD), frequencies (number of cases) and relative frequencies (percentages) as appropriate. To determine whether the data were normally distributed, a Kolmogorov-Smirnov test was used. Comparison of quantitative variables between the study groups was done using MannWhitney *U* test for non-parametric data. For comparing categorical data, Chi square ($\chi 2$) test was performed and fisher exact test was used when the expected frequency is less than 5 with relative risk. A probability value (*p* value) less than 0.05 was considered statistically significant. All statistical calculations were done using (Statistical Package for the Social Science) SPSS 21version (SPSS Inc., Chicago, IL, USA) statistical program for Microsoft Windows.

The data collected was compiled and analysed to study the incidence, risk factors and the outcome of the external ventricular drain infections. All statistical calculations will be done using (Statistical Package for the Social Science) SPSS 21 version (SPSS inc., Chicago IL, USA) statistical program for Microsoft windows.

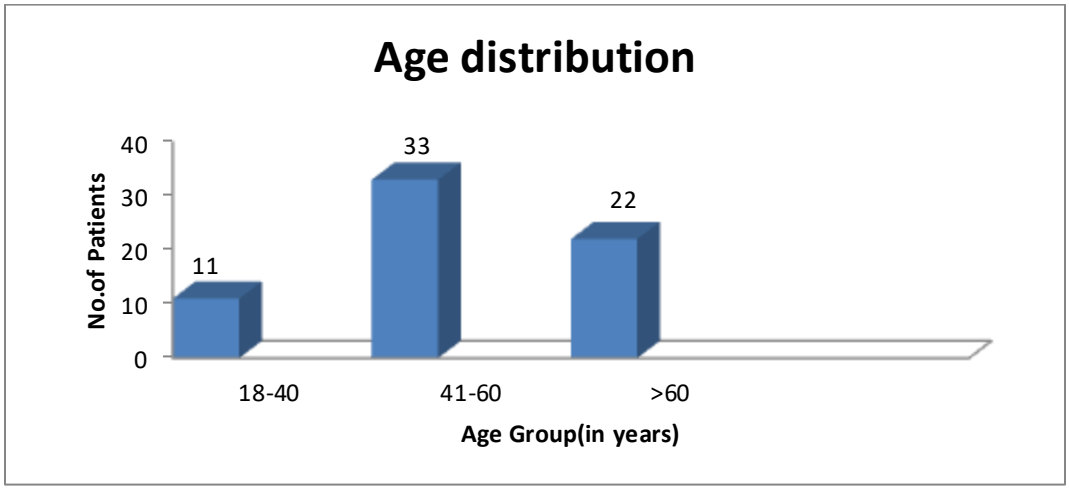
OBSERVATIONS AND RESULTS

The present study entitled “Study of Risk factors and outcome in External Ventricular drain infections” was undertaken to study the various risk factors associated with external ventricular infections and to study the outcome in patients getting external ventricular drain infections. In our prospective study, 66 patients admitted to the Neurosurgery ICU of Dayanand Medical College and Hospital for EVD placement and following the inclusion criteria of the study were included in the study.

Table 1: Age distribution

AGE GROUP	No. of cases	Percentage
< 40	11	16.7%
41-50	10	15.2%
51-60	23	34.8%
61-70	15	22.7%
> 70	7	10.6%
Total	66	100.0%

Figure 1: Age distribution

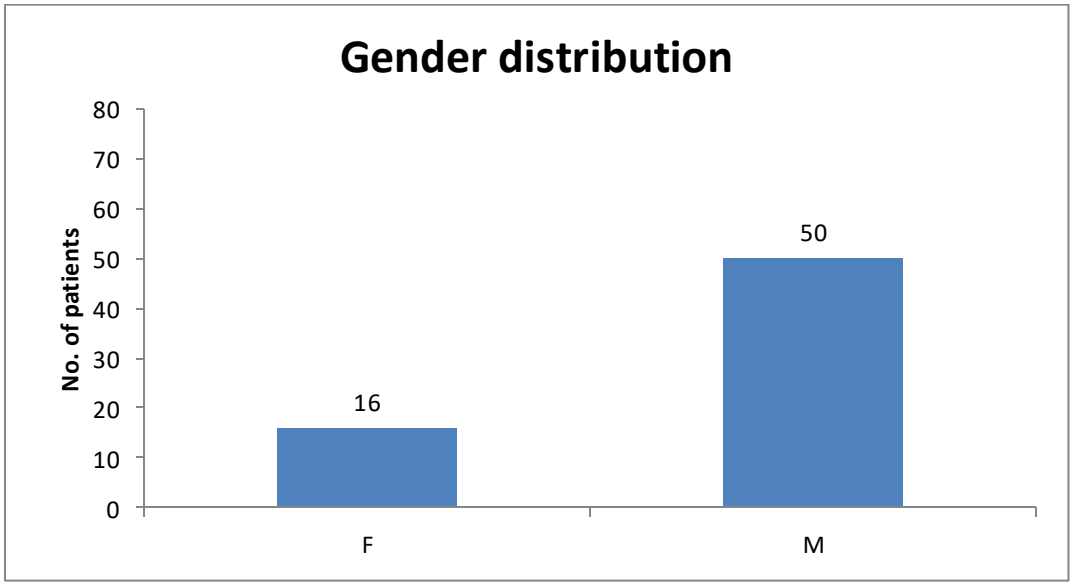


In our study, out of total 66 patients, 11 patients were of 18-40 years of age group, 33 patients were of 41-60 years of age group and 22 patients were of more than 60 years of age group. 50 patients were male and 16 were female.

Table 2: Gender distribution:

Gender	No. of cases	Percentage
F	16	24.2%
M	50	75.8%
Total	66	100.0%

Figure 2: Gender distribution

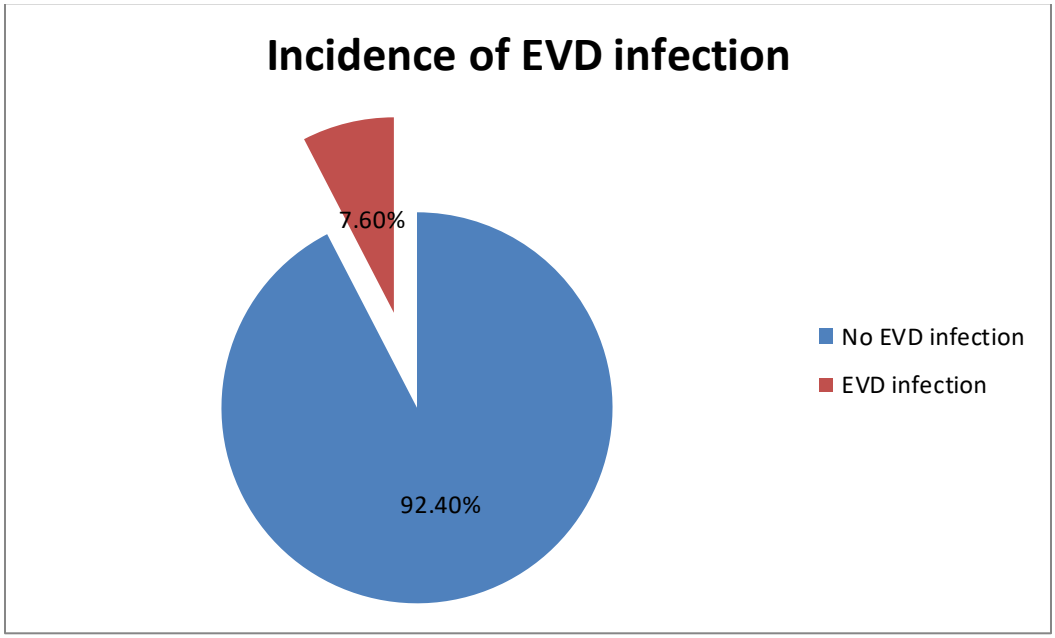


Out of 66 patients, 53 patients(80.30%) got EVD placement due to SAH or ICH, 7 patients(10.60%) got EVD placement due to hydrocephalus secondary to brain infarct, 4 patients (6.06%)received EVD insertion for traumatic hydrocephalus, 2 patient(3.03%) due to space occupying lesion.

Table 3: Incidence of EVD infection

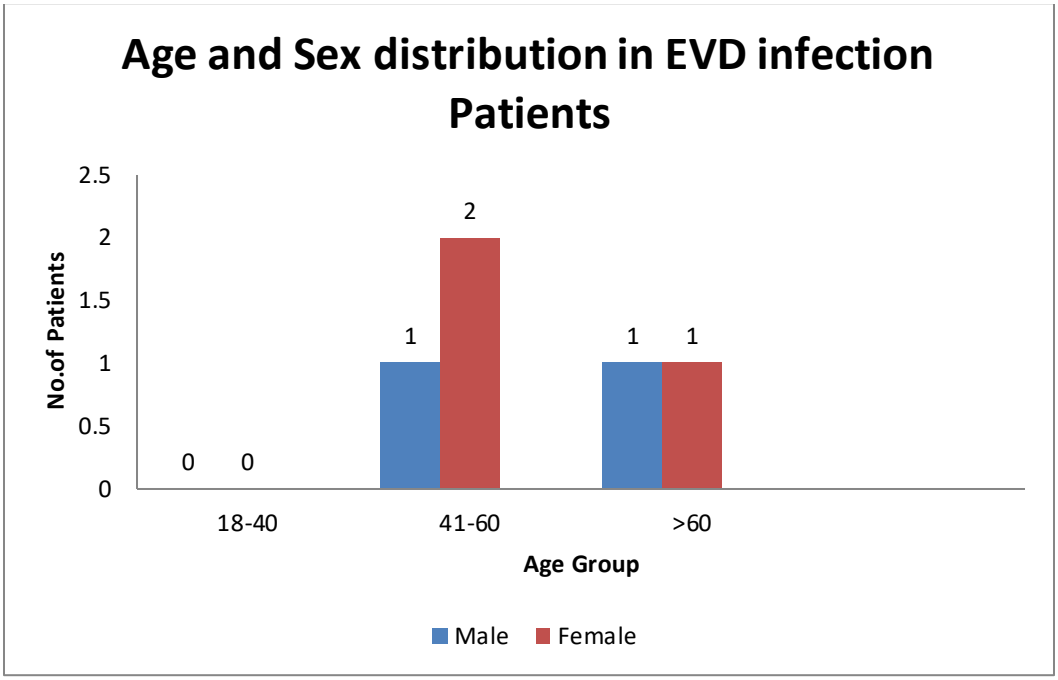
Infection	No. of cases	Percentage
No	61	92.4%
Y	5	7.6%

Figure 3: Incidence of EVD infection



In our study, 5 patients developed external ventricular drain infections giving an incidence of 7.6% of infection. Two patients had EVD blockage. However, none of the patient had local wound infection or haemorrhage during EVD insertion.

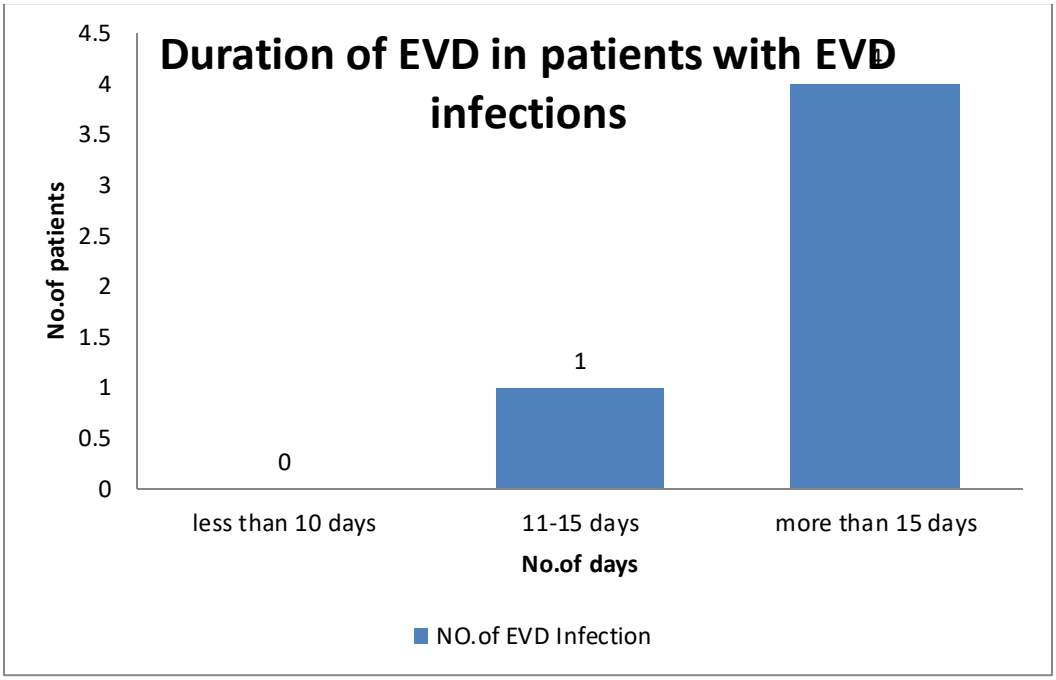
Figure 4: Age and Sex distribution in EVD infection Patients



In patients with EVD infections, 3 patients were of 41-60 years of age group and 2 patient were of more than 60 years of age group. Out of 5 infected patients, 3 patients were female and 2 were male. Among these 5 infected patients, 4 patients received EVD insertion due to SAH or ICH while 1 patient received EVD placement due to space occupying lesion.

The mean age of patients with no EVD infection was 53.72(+-14.84) years and in patients with EVD infection was 59.60(+-12.26) years. No significant statistical association was seen in patients with EVD infection and with no infection in terms of age, gender and indication for inserting an EVD.

Figure 5: Duration of EVD in patients with EVD infections



In total 66 patients, the mean duration of EVD was 15.5+-6.7 days. In Patients with no EVD infection, 25(41%) patients received EVD for less than 10 days,12(19.7%) patients received EVD for 11-15 days and 24(39.3%) patients received for more than 15 days while in patients with EVD infection, none of the patient received EVD for less than 10 days,1(20%) patient received EVD for 11-15 days, 4(80%) patients received for more than 15 days. The mean duration of EVD drainage in infectious group was 24.0+-7.52 days while in non infectious group was 14.77+-6.24 days. The duration of EVD drainage was found to be significantly more in patients with EVD infections (p=0.003).

The mean frequency of CSF sampling was 10.60+-4.70 times in EVD infection patients compared to 5.51+-2.15 times in patients with no EVD infection. Thus, increased frequency of CSF sampling was significantly found to be a risk factor for EVD infections (p=0.00).

Systemic coinfection was present in all the 5(100%) infected patients while it was present in only 19 (31.1%) patients with no EVD infection. Thus, systemic coinfection was found to be significantly more in patients with EVD infection.(p=0.002)

Use of prophylactic intravenous antibiotics .(p=0.773) and intraventricular antibiotics (p=0.174)were not found to have significant role in preventing EVD infections in our study.

NO significant rate of EVD infection was found in patients undergoing other neurosurgical procedure (p=0.064).

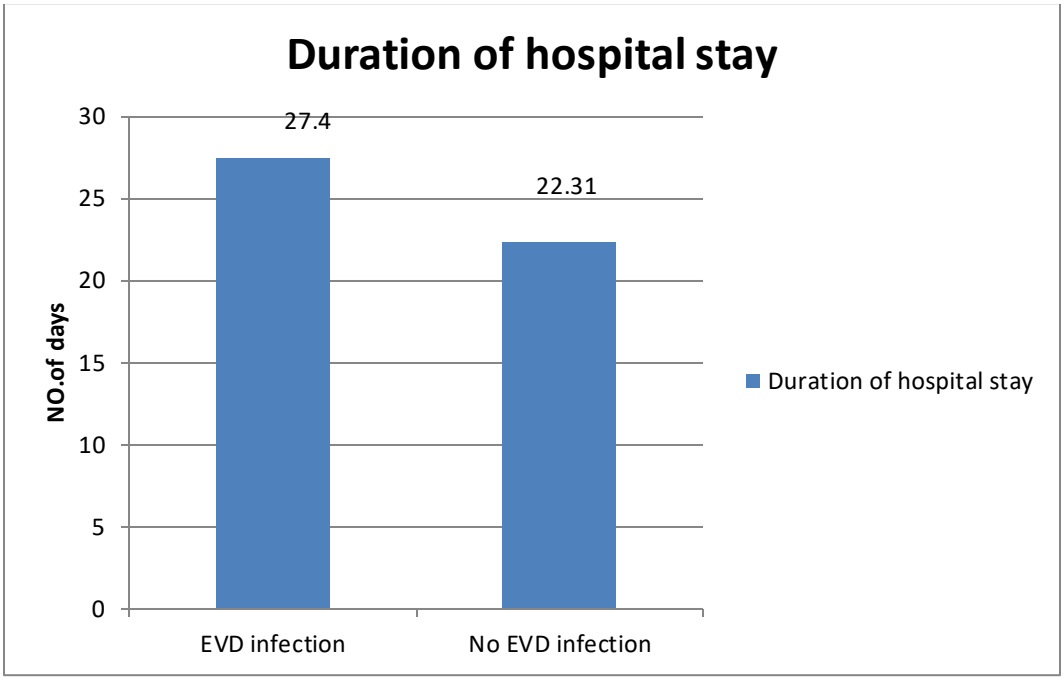
In patients with EVD infections,2 patients were diagnosed on positive cerebrospinal fluid culture. One patient had positive culture for E.coli on 4^{th} day of third EVD while the other patient had positive cerebrospinal fluid culture for pseudomonas putida on 10^{th} day of first EVD. Both of the patients with positive culture also showed decreased glucose levels in cerebrospinal fluid.

The other 3 patients were having negative cerebrospinal fluid culture and they were diagnosed on biochemistry tests .these patients were having decreased glucose levels in CSF (less than 50% of blood glucose)

Systemic coinfection was present in all the 5(100%) infected patients while it was present in only 19 (31.1%) patients with no EVD infection. Thus, systemic coinfection was found to be significantly more in patients with EVD infection.(p=0.002)

All the patients with EVD infections had positive systemic coinfection. 4 patients were having lower respiratory tract infections and one patient was having systemic candidiasis.

Figure 6: Duration of hospital stay

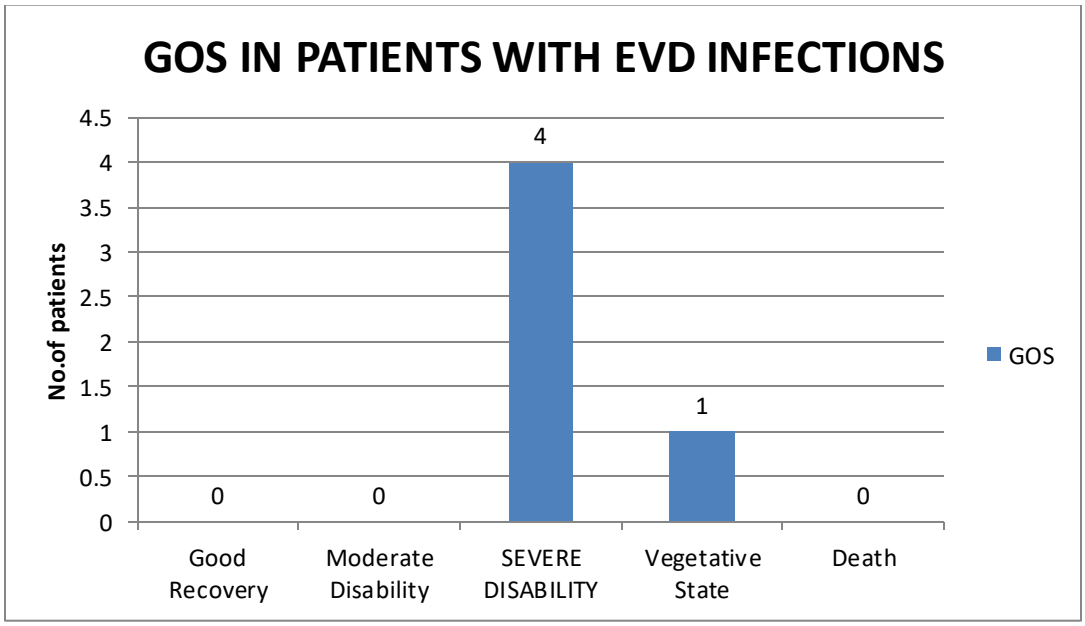


The mean total duration of ICU stay in patients with EVD infections was 16.60+-7.50 days compared to 14.0+-3.86 days in no EVD infection group and the difference was not found to be statistically significant (p= 0.186). However, the mean total duration of hospital stay in EVD infection patients was 27.40+-5.94 days and was 22.31+-5.09 days in patients with no EVD infections .The mean duration of hospital stay was found to be longer in patients with EVD infections and the difference is statistically significant (p= 0.038).

Table 4: GOS in patients with EVD infections

	GOS in patients with EVD infections	%age
Good recovery	0	0.0%
Vegetative state	1	20.0%
Severe disability	4	80.0%
Moderate disability	0	0.0%
Death	0	0.0%

Figure 7: GOS in patients with EVD infections

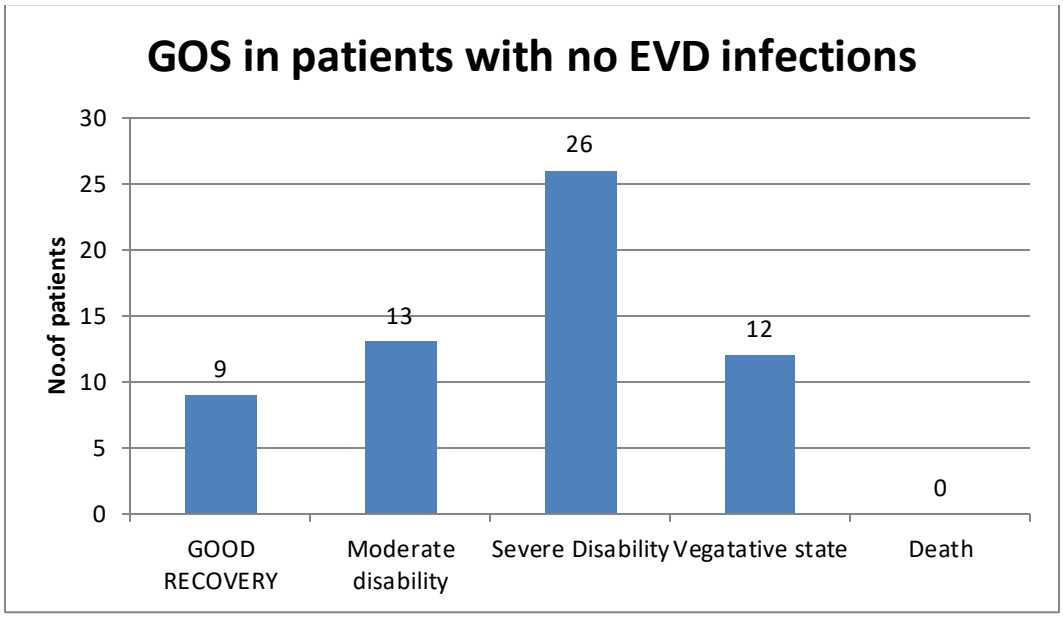


Out of 5 patients with EVD infections, 4 patients were having severe disability according to the Glasgow outcome scale at discharge while one patient was in vegetative state at the time of discharge.

Table 5: GOS in patients with no EVD infections

	GOS in patients with no EVD infections	percentage
Good recovery	9	15.0%
Moderate disability	13	21.7%
Severe Disability	26	43.3%
Vegatative state	12	20.0%
Death	0	0.0%

Figure 8: GOS in patients with no EVD infections



In patients with no EVD infections, 12 patients were in vegetative state, 26 patients were having severe disability, 13 patients were having moderate disability and 9 patients were having good recovery rate at the time of discharge. No significant difference was seen in two groups in terms of Glasgow Outcome scale at the time of discharge (p= 0.244). Thus, EVD infections although lead to increased hospital stay in our study but did not significantly worsen the Glasgow outcome scale at the time of discharge. This might be because of primary cause affecting the GCS, early diagnosis of EVD infection and timely intervention to prevent the adverse outcome.

DISCUSSION

External ventricular drains are frequently used in neurosurgery to drain the cerebrospinal fluid in patients with raised intracranial pressure. However, they are associated with many complications with infection being the most common complication.

The present prospective observational study was conducted on 66 patients admitted to the Neurosurgery ICU of Dayanand Medical College and Hospital for EVD placement and following the inclusion criteria of the study.

Age and Sex Distribution

Out of total 66 patients, 11 patients were of 18-40 years of age group, 33 patients were of 41-60 years of age group and 22 patients were of more than 60 years of age group. 50 patients were male and 16 were female. In patients with EVD infections, 3 patients were of 41-60 years of age group and 2 patient was of more than 60 years of age group. Out of 5 infected patients, 3 patients were female and 2 were male while in patients with no EVD infection 13 (21.3%) patients were female and 48(78.7%) patients were male. The mean age of patients with no EVD infection was 53.72 (+-14.84) years and in patients with EVD infection was 59.60 (+-12.26) years. No significant statistical association was seen in patients with EVD infection and with no infection in terms of age, gender.

Similar results were seen in many studies. In a study by Shang et al, the mean age of patients with no EVD infection was 56.2+-17.9 years and in patients with EVD infection was 63.2+-9.0 years. Out of 53 patients with no EVD infection 29 were male and 24 were female and in patients with EVD infections 3 were male and 2 were female. No significant association of demographic factors with EVD infection was seen in this study. [46]

However, few studies had shown different results. Age was identified by Flibotte et al. [OR & 95%CI: 1.04, 1.01–0.081; P-value: 0.03] and Wright et al. [HR & 95%CI: 1.051, (1.01–1.09) P-value, 0.014] as a risk factor associated with ventricular catheter infection.[49,50]

Lo et al. reported that females [OR & 95%CI: 3.4, (1.2–9.7); P-value, 0.02] were three times as likely to be infected as males.[43]

In our study, we find 5 EVD infections among 66 enrolled patients giving an incidence of 7.6 % of EVD infections. This falls within the range of EVD infections in literature.

Similar results were seen in many studies. In a study conducted by Hagel et al, 18 patients out of 218 patients developed EVD infections giving a cumulative incidence of 8.3%(95% CI, 5.3–12.7). All the patients developed only one episode of infection.[44]

In a study conducted by Chouhdari et al, 39 patients out of 81 patients developed EVD infections giving an incidence of as high as 48.1%.[30]

Similarly, retrospective study conducted by Shang et al on 58 patients, 5 patients out of 58 patients developed EVD infection giving an incidence of 8.6%.[46]

In a prospective multicentre cohort study conducted on 452 patients over 6 months in UK and ireland, 46 EVD related infections were seen giving an infection risk of 9.3%.[20]

A retrospective study by Hoefnagel et al reported an incidence of EVD infection as 23.2 %.[41]

In a study conducted in Brazilian tertiary hospital by Camacho et al on 119 patients, the incidence of infection was 18.3%.[42]

One of the key finding of our study was the relation of duration of EVD with risk of infection. In 66 patients, the mean duration of EVD was 15.5+-6.7 days. In Patients with no EVD infection, 25(41%) patients received EVD for less than 10 days, 12(19.7%) patients received EVD for 11-15 days and 24 (39.3%) patients received for more than 15 days while in patients with EVD infection, none of the patient received EVD for less than 10 days,1(20%) patient received EVD for 11-15 days, 4(80%) patients received for more than 15 days. The mean duration of EVD drainage in infectious group was 24.0+-7.52 days while in non infectious group was 14.77+-6.24 days. The duration of EVD drainage was found to be

significantly more in patients with EVD infections (p=0.003). Thus, increased risk of EVD infection was seen with longer duration of EVD. This finding was seen in many other studies.

One of the study had shown increased risk of ERI in patients with EVD left for more than 8 days compared to EVD removed at 7 days or less than that period((OR=2.54 (95% CI 1.14 to 5.7); p=0.02).[20]

In a study by Hoefnagel et al, duration of EVD drainage appeared to be a risk factor for infection (>11 days: OR 4.1; 95% CI 1.8–9.2, p = 0.001).[41]

In another study conducted to describe incidence rates and risk factors associated with external ventricular drain (EVD)-related infections at a tertiary Brazilian teaching hospital, the drain-associated infection rate was 22.4 per 1,000 catheter-days. The duration of time EVD catheter remain in place was found to be the only risk factor associated with EVD infections (0.0369)in this study.[42]

Similarly in a study conducted by Shang et al, the mean duration of catheter drainage in the infection group was (15.2±7.3) days compared to duration of (7.3±3.9) days in non infection group. Thus, the study concluded that increased duration of catheter in place could significantly increase the risk of infection and catheter duration of >11 days (Wals=4.8, RR=17.3, 95% CI: 1.4-218.3, P=0.028), considerably enhances the risk of infection.[46]

In another study, it was seen that the mean number of EVD days for patients who developed infection was 19.61 days in contrast to the patients who did not develop infection who had EVD for a mean of 7.09 days. This difference is significant and leads to a conclusion that the longer the duration of EVD the higher the rate of infection.[45]

Other finding in our study was increased frequency of CSF sampling was also found to be significantly associated with EVD infections. The mean frequency of CSF sampling was 10.60+-4.70 times in EVD infection patients compared to 5.51+-2.15 times in patients with no EVD in our

study. Thus, increased frequency of CSF sampling was significantly found to be a risk factor for EVD infections (p=0.00).

A study by Jamjoom et al. had found increased significant increased risk of infection in daily sampling and alternate day sampling in comparison to sampling done once or twice a week.[20]

In a study by Hoefnagel et al. increased frequency of CSF sampling [OR & 95%CI: 4.12, (1.84–9.22); P-value, 0.001] was identified a risk factor to EVD infection.[41]

In a study by Shang et al, the mean duration of cerebrospinal fluid sampling was (1.7±0.37) days in infection group compared to mean duration of (3.8±2.2) days in noninfection group. Thus, the study concluded that the shorter time interval of cerebrospinal fluid specimen collection was associated with increased risk of EVD infection (≤2 d, Wals=5.3, RR=15.3, 95% CI: 1.5-243.7, P=0.022). Patients without cerebrospinal fluid specimen collection during EVD did not present with infection ($\chi 2$=38.4, RR=0.12, 95% CI: 0.051-0.270, P=0.001).[46]

Systemic coinfection was present in all the 5(100%) infected patients while in our study it was present in only 19 (31.1%) patients with no EVD infection. Thus, systemic coinfection was found to be significantly more in patients with EVD infection.(p=0.002)

Coinfection was found to be the high risk patient factor for EVD infections in many studies. In studies by Bota et al. [OR & 95%CI: 3.92, (0.66–7.84); P-value, 0.02], Holloway et al. [P-value, 0.001], Kirmani et al. [P-value, 0.002], and Mounier et al. [OR & 95%CI: 11.8, (2.5–56.8); P-value, 0.002] systemic coinfection was found to be significantly associated with ventricular catheter infection. The EVD infection rates of 12, 20.7, 15, & 37.5% in patients who had a concurrent infection vs. 7, 8.6, 6 & 4.7% in patients who did not were reported respectively.[51-54]

In our study, Use of prophylactic intravenous antibiotics (p=0.773) and intraventricular antibiotics (p=0.174) were not found to have significant role in preventing EVD infections.

In a study comparing infection rates in three years study of antibiotic-impregnated drain combined with continuous antibiotic prophylaxis (410 patients) vs one year of antibiotic-impregnated drain placement without prolonged antibiotic prophylaxis (135 patients), discontinuation of continuous antibiotic prophylaxis did not lead to an increase in infection rate (1.1% vs 0.4%, p = 0.22).[55]

Another study compared 209 patients with prolonged antibiotic prophylaxis to 99 patients with peri-procedural antibiotic prophylaxis only. There was no difference in the infection rate between these groups.[56]

However few studies had shown decrease in rates of EVD infections with the use of prophylactic antibiotics. In an RCT including 228 patients, 3 out of 115 patients (3%) with continuous antibiotic prophylaxis developed a CSF infection vs 12 out of 113 patients receiving peri-operative antibiotic prophylaxis only (11%). The study concluded that the incidence of a catheter-associated infection was significantly reduced by continuation of antibiotic prophylaxis as long as the EVD was in place.[57]

In our study, no significant rate of EVD infection was found in patients undergoing other neurosurgical procedure (p=0.064).

However, many studies had found neurosurgical operation as a risk factor for EVD infections. Bota et al. [OR & 95%CI: 4.74, (0.27–9.52); P-value, 0.03], Holloway et al. [craniotomy: P-value, 0.005; DSF: P-value, 0.003], Mayhall et al. [P-value, 0.016], Omar et al. [OR & 95%CI: 10.46, (3.38–32.32); P-value, 0.001], and Peter et al. [P-value, 0.047] had identified neurosurgical operation as a risk factor. The studies had found that infection rate varied between 15.2 and 82% in patients who underwent neurosurgical operation compared to 3.4 and 69% in patient who did not.[39,51,52,58]

In our study, 2 patients were diagnosed to be having EVD infections based on positive cerebrospinal fluid culture result. Both the patients were found to be positive for Gram negative organism.

In a study by Camacho et al. 77% of infections were caused by Gram negative organism.[42]

Tsioutis et al. reported that Gram-negative bacteria (GNB) predominated (57.9%) in the EVDs infection, followed by Gram-positive (36.8%) and fungi (5.3%).[59]

In our study, the mean total duration of ICU stay in patients with EVD infections was 16.60+-7.50 days compared to 14.0+-3.86 days in no EVD infection group and the difference was not found to be statistically significant. However, the mean total duration of hospital stay in EVD infection patients was 27.40+-5.94 days and was 22.31+-5.09 days in patients with no EVD infections .The mean duration of hospital stay was found to be longer in patients with EVD infections and the difference is statistically significant (p= 0.038).

Similar results were seen in many studies. Increased hospital stay was seen in study by Camacho et al in EVD infection patients.

In a study by Hagel et al, patients with an EVD-related infection had a significantly longer ICU (11 versus 21 days, P < 0.01) and hospital stay (20 versus 28.5 days, P < 0.01) than patients without EVD-related infection. It was not associated with increased in hospital mortality (17% versus 18%; P = 1.0).[44]

In a study by Walek et al to study the risk factors of EVD infection, EVD infection was found to be associated with longer length of stay (23 days vs 16 days; P = .045).[48]

However, a study by Bari et al. found no association between EVD infections and length of hospital stay (P value: >0.05).[45]

SUMMARY AND CONCLUSION

The observations made in this study were:

1. The mean age of patients with no EVD infection was 53.72(+-14.84) years and in patients with EVD infection was 59.60(+-12.26) years. No significant statistical association was seen in patients with EVD infection and with no infection in terms of age, gender and indication for inserting an EVD.

2. 5 patients got external ventricular drain infections giving an incidence of 7.6% infection.

3. The mean duration of EVD drainage in infectious group was 24.0+-7.52 days while in non infectious group was 14.77+-6.24 days. The duration of EVD drainage was found to be significantly more in patients with EVD infections (p=0.003).

4. The mean frequency of CSF sampling was 10.60+-4.70 times in EVD infection patients compared to 5.51+-2.15 times in patients with no EVD. Thus, increased frequency of CSF sampling was significantly found to be a risk factor for EVD infections (p=0.00).

5.Systemic coinfection was present in all the 5(100%) infected patients while it was present in only 19 (31.1%)patients with no EVD infection. Thus, systemic coinfection was found to be significantly more in patients with EVD infection.(p=0.002)

6.Use of prophylactic intravenous antibiotics .(p=0.773) and intraventricular antibiotics (p=0.174)were not found to have significant role in preventing EVD infections in our study.

7.NO significant rate of EVD infection was found in patients undergoing other neurosurgical procedure (p=0.064).

8. The mean total duration of hospital stay in EVD infection patients was 27.40+-5.94 days and was 22.31+-5.09 days in patients with no EVD infections .The mean duration of hospital stay was found to be longer in patients with EVD infections and the difference is statistically significant.

9. Out of 5 patients with EVD infections, 4 patients were having severe diasability according to the Glasgow outcome scale at discharge while one patient was in vegetative state at the time of discharge.

In patients with no EVD infections, 12 patients were in vegetative state,26 patients were having severe disability, 13 patients were having moderate disability and 9 patients were having good recovery at the time of discharge.No significant difference was seen in two groups in terms of Glasgow Outcome scale at the time of discharge (p=0.244)

Thus the conclusion of the study was:

1.An incidence of 7.6 % EVD infection was reported in our study.

2.Prolonged duration of EVD drainage, increased frequency of CSF sampling, systemic coinfection were identified as a risk factor in EVD infection.

3.EVD infection lead to prolonged hospital stay in our study, however it did not lead to worse Glasgow outcome scale at the time of discharge.

4. Diagnosing EVD infection at an early stage is very difficult. New tests are needed to improve the diagnosis and treatment. Use of only CSF measures for diagnosis lead to frequent sampling of CSF which is a risk factor for the development of EVD infection.

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S. NO	MRD No.	Initial	Age	Sex	Diagnosis	GCS at admission	Duration of EVD	No. of EVD placed	Systemic coinfection	Antibiotic prophylaxis	Intraventricular Antibiotic used	Gram Stain				ZN stain				KOH stain			
												At insertion	4th day	7th day	10th day	At the time of insertion	4th day	7th day	10 th day	At the time of insertion	4th day	7th day	10 th day
1	1148416	SG	65	M	Right thalamic bleed,IVH,Hydrocephalus	11	10	1	Yes (LRTI,UROsepsis)	YES	NO	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
2	1148504	AS	30	M	Ruptured R ACA saccular aneurysm,hydrocephalus	13	8	1	No	YES	NO	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
3	1150459	AK	49	M	Right thalamic bleed,IVH,Hydrocephalus	11	22	3(1)	Yes (urosepsis)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
4	1165548	KS	42	M	Left ganlocapsular bleed with IVhH	8	18	2(1)	Yes (urosepsis)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
5	1173422	BS	27	M	post traumatic hydrocephalus	13	10	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	NAD
6	1190702	PR	64	M	posterior fossa infarct with hydrocephalus	8	17	2(1)	Yes (urosepsis)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	NAD
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
7	1192432	TS	60	M	SAH with hydrocephalus	11	14	2(1)	No	yes	NO	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
8	1197075	AG	58	F	IVH with hydrocephalus	10	17	2(1)	yes	yes	NO	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)			-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
9	1201130	D	62	M	Posterior fossa bleed with hydrocephalus	11	10	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
10	1216627	S	51	M	Left Thalamocapsular bleed with IVH	9	25	3(1)	Yes (LRTI)	yes	-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-	-
11	1222167	JK	75	F	Right thalamic bleed,IVH,Hydrocephalus	9	18	2(1)	Yes (LRTI)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
12	1223015	RL	69	M	Right Cerebellar Ich with IVH	12	17	2(1)	Yes (LRTI,UROsepsis)	yes	yes	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
13	1228583	SS	27	M	Right MCA aneurysm with SAH,IVH,Hydrocephalus	13	10	1	NO	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
14	1242719	GS	73	M	Brain stem infarct with hydrocephalus	3	17	2(1)	Yes (LRTI,UROsepsis)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
15	1246142	R	70	F	Right medial temporal region ICH with IVH	11	10	1	NO	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
16	1248920	RI	57	M	Brain stem infarct with hydrocephalus	11	37	4(1)	NO	yes	yes	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(4)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
17	1206749	AKS	48	M	Right temporal lobe Ich with IVH	12	10	1	Yes (urosepsis)	yes	-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
18	1187280	SS	60	M	Right PICA Ruptured aneurysm SAH IVH	7	18	2(1)	Yes (urosepsis)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)			-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
19	1253120	RK	55	F	Ruptured Saccular Right ICA bifurcation aneurysm	11	20	2(1)	Yes (LRTI)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
20	1254065	RB	58	F	SAH ,IVH,Ruptured ACOM Aneuyrsm	3	11	1	Yes (LRTI,UROsepsis)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
21	1249360	HS	65	M	left temporal SDH with IVH	10	14	2(1)	No	yes	NO	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
22	1263226	DS	60	M	Left cerebellar bleed with hydrocephalus	10	16	2(1)	No	YES	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
23	914924	PS	73	M	post fossa bleed with hydrocephalus	11	15	2(1)	NO	yes	NO	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
24	1273608	AB	50	M	Left ganlocapsular bleed with IVhH	9	20	2(1)	NO	yes	O	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
25	1266248	RS	19	M	IVH withcommunicating hydrocephalus	11	14	2(1)	No	yes	No	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
26	1270980	CD	64	F	Right thalamocapsular bleed Ivh Hydrocephalus	10	10	1	No	yes	NO	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative

S. NO	MRD No.	Cytology								Biochemistry				CULTURE				Blood Sugar				Frequency of CSF sampling	Other neurosurgical procedure	Length of icu stay	Length of hospital stay	Complications	GOS at discharge
		At the time of insertion		4th day		7th day		10 th day		At the time of insertion	4th day	7th day	10 th day	At the time of insertion	4th day	7th day	10 th day	At the time of insertion	4th day	7th day	10 th day						
		TLc	RBC	TLc	RBC	TLC	RBC	TLC	RBC	Glucose	Glucose	Glucose	Glucose														
1	1148416	2	1000	4	100	2	100	2	50	98	88	86	98	no growth	no growth	no growth	no growth	122	112	132	108	4	No	10	16	NO	3
2	1148504	1	100	2	100	2	50	-	-	102	78	88	-	no growth	no growth	no growth	-	98	110	112	121	3	Yes	10	16	NO	4
3	1150459	4	100	2	50	2	50	1	20	88	86	98	96	no growth	no growth	no growth	no growth	78	100	122	110	7	YEs	16	26	NO	3
		2	20	3	20	4	30	1	10	78	98	102	92	no growth	no growth	no growth	no growth	122	124	132	112	-	-	-	-	-	-
		1	10	-	-	-	-	-	-	96	-	-	-	no growth	-	-	-	126	132	124	102	-	-	-	-	-	-
4	1165548	4	1000	10	500	6	100	4	100	96	92	88	78	no growth	no growth	no growth	no growth	88	98	92	112	6	No	15	23	No	3
		2	100	2	100	2	50	-	-	92	78	88	-	no growth	no growth	no growth	-	112	124	102	106	-	-	-	-	-	-
5	1173422	4	100	2	40	2	10	2	10	102	96	92	90	no growth	no growth	no growth	no growth	110	112	132	122	4	No	10	16	No	5
6	1190702	2	10	4	10	1	5	2	0	78	76	88	98	no growth	no growth	no growth	no growth	112	124	128	142	6	No	17	24	No	2
		1	2	2	10	2	10	-	-	96	92	88	-	no growth	no growth	no growth	-	124	122	102	114	-	-	-	-	-	-
7	1192432	10	100	5	100	4	100	2	50	94	98	96	88	no growth	no growth	no growth	no growth	118	114	124	122	5	No	10	20	No	3
		2	20	2	20	-	-	-	-	68	78	-	-	no growth	no growth	no growth	no growth	102	112	106	108	-	-	-	-	-	-
8	1197075	20	1000	10	500	10	500	5	100	92	102	112	102	no growth	no growth	no growth	no growth	110	122	142	132	6	no	15	24	no	4
		2	100	2	100	4	50	-	-	84	88	98	-	no growth	no growth	no growth	-	124	128	112	128	-	-	-	-	-	-
9	1201130	4	100	2	50	2	20	1	10	78	82	88	82	no growth	no growth	no growth	no growth	98	112	122	132	4	No	10	18	No	4
10	1216627	20	1000	20	1000	10	400	10	100	102	99	97	86	no growth	no growth	no growth	no growth	102	110	128	132	8	No	20	32	No	3
		8	100	6	100	4	50	2	10	98	92	94	88	no growth	no growth	no growth	no growth	126	124	128	118	-	-	-	-	-	-
		2	20	2	10	-	-	-	-	86	102	-	-	no growth	no growth	-	-	110	112	110	116	-	-	-	-	-	-
11	1222167	20	1000	12	1000	10	500	10	100	100	78	86	82	no growth	no growth	no growth	no growth	124	122	142	132	6	No	15	25	NO	4
		10	100	5	100	4	20	-	-	92	87	86	-	no growth	no growth	no growth	-	122	112	132	122	-	-	-	-	-	-
12	1223015	10	1000	10	100	10	100	2	50	78	76	88	82	no growth	no growth	no growth	no growth	98	99	102	86	6	Yes	17	25	No	3
		4	20	2	10	2	10	-	-	88	82	98	-	no growth	no growth	no growth	-	112	124	110	120	-	-	-	-	-	-
13	1228583	10	1000	10	500	4	100	2	100	102	96	98	88	no growth	no growth	no growth	no growth	124	122	110	108	4	Yes	8	15	NO	5
14	1242719	4	20	2	10	2	10	2	10	88	98	92	78	no growth	no growth	no growth	no growth	118	124	122	110	6	No	19	26	No	2
		1	10	2	10	4	10	-	-	74	86	82	-	no growth	no growth	no growth	-	108	122	128	118	-	-	-	-	-	-
15	1246142	10	100	10	100	8	80	4	100	78	72	88	86	no growth	no growth	no growth	no growth	122	118	116	114	4	NO	10	17	NO	4
16	1248920	4	100	2	100	2	50	2	50	78	76	88	82	no growth	no growth	no growth	no growth	122	108	114	116	14	No	24	29	NO	2
		4	20	2	10	2	10	2	10	88	82	98	96	no growth	no growth	no growth	no growth	106	128	108	126	-	-	-	-	-	-
		4	20	2	10	4	10	4	10	98	88	98	76	no growth	no growth	no growth	no growth	118	124	122	110	-	-	-	-	-	-
		2	10	2	10	2	10	-	-	96	88	86	-	no growth	no growth	no growth	-	108	122	128	118	-	-	-	-	-	-
17	1206749	20	1000	16	1000	10	500	10	100	78	86	88	82	no growth	no growth	no growth	no growth	122	112	110	118	4	No	10	15	No	5
18	1187280	10	1000	10	800	8	500	4	100	88	82	94	92	no growth	no growth	no growth	no growth	128	122	121	118	6	YEs	19	26	NO	3
		4	100	2	100	2	150	-	-	78	76	92	-	no growth	no growth	no growth	-	124	108	110	108	-	-	-	-	-	-
19	1253120	2	0	2	100	2	100	20	100	94	92	83	36	no growth	no growth	no growth	pseudomonas putida growth	158	142	116	136	7	Yes	16	22	Yes (infection)	3
		2	50	3	20	2	0	2	0	78	74	68	82	no growth	no growth	no growth	-	130	134	128	118			-	-	-	-
20	1254065	10	1000	10	400	10	100	10	100	76	88	98	86	no growth	no growth	no growth	no growth	124	112	118	110	6	YEs	17	24	No	2
21	1249360	20	1000	10	1000	10	1000	10	500	98	88	98	76	no growth	no growth	no growth	no growth	110	118	112	108	5	No	16	23	No	3
		6	100	4	100	-	-	-	-	68	86	-	-	no growth	no growth	-	-	118	114	110	108	-	-	-	-	-	-
22	1263226	20	1000	10	1000	10	1000	8	1000	87	88	92	82	no growth	no growth	no growth	no growth	124	126	118	116	6	Yes	18	26	No	3
		5	400	4	100	-	-	-	-	98	86	-	-	no growth	no growth	-	-	126	22	118	102	-	-	-	-	-	-
23	914924	10	1000	10	800	8	500	4	100	86	88	74	77	no growth	no growth	no growth	no growth	128	116	114	110	5	no	13	22	No	5
		4	100	2	100	-	-	-	-	68	85	-	-	no growth	no growth	-	-	100	118	112	128	-	-	-	-	-	-
24	1273608	10	1000	10	500	10	500	8	500	84	74	83	92	no growth	no growth	no growth	no growth	124	126	118	116	7	NO	16	27	Blockage	4
		4	100	4	50	2	10	2	10	98	88	98	76	no growth	no growth	no growth	no growth	112	108	110	116	-	-	-	-	-	-
25	1266248	10	1000	10	500	10	400	6	100	78	72	88	86	no growth	no growth	no growth	no growth	106	128	108	126	5	No	14	20	No	5
		2	100	4	100	-	-	-	-	88	68	-	-	no growth	no growth	-	-	118	124	122	110	-	-	-	-	-	-
26	1270980	20	1000	10	400	10	200	4	100	88	82	94	92	no growth	no growth	no growth	no growth	132	126	128	116	4	No	10	16	No	3

S. NO	MRD No.	Initial	Age	Sex	Diagnosis	GCS at admission	Duration of EVD	No. of EVD placed	Systemic coinfection	Antibiotic prophylaxis	Intraventricular Antibiotic used	Gram Stain				ZN stain				KOH stain			
												At insertion	4th day	7th day	10th day	At the time of insertion	4th day	7th day	10 th day	At the time of insertion	4th day	7th day	10 th day
27	1292072	CK	68	F	Right gangiocapsular bleed with IVH	10	10	1	yes (urosepsis,LRTI)	yes	NO	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
28	1298341	CS	55	M	Cerebellar ICH ,hydrocephalus	3	9	1	No	no	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
29	1298756	GS	28	M	IVH	4	8	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
30	1292818	PK	53	M	Posterior fossa bleed with hydrocephalus	12	15	2(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
31	1300245	PK	55	M	Ruptured ACOM aneuyrsm,SAH,hydrocephalus	13	15	2(1)	NO	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
32	1297841	DS	64	M	Right thalamic bleed,IVH,Hydrocephalus	10	10	1	Yes (urosepsis)	yes	-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
33	1307244	SR	53	F	Left ICA aneurysim with SAH,IVH,Hydrocephalus	11	27	3(1)	Yes (LRTI,UROsepsis)	yes	-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
34	1311698	KLG	68	M	SAH hydrocephalus	4	12	2(1)	Yes	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	-	-	negative	negative	-	-	negative	negative	-	-
35	1314054	IS		M	Posterior fossa ICH,hydrocephalus	3	34	4(1)	Yes (LRTI,UROsepsis)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)			-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)			-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(4)			-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
36	1133995	RS	26	M	Post traumatic cerebellar infarct with hydrocephalus	11	10	1	No	Yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
37	1321132	SJ	42	M	Left thalamocapsular bleed IVH	8	14	2(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
38	1325919	B	62	M	posterior fossa infarct with hydrocephalus	10	10	1	NO	yes	No	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
39	1326746	JS	64	M	Ruptured ACOM aneurysm SAH,IVH hydrocephalus	8	17	2(1)	No	yes	No	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
40	1124954	RPR	90	M	Post.fossa Sol with Hydrocephalus	3	10	1	Yes	YEs	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
41	1329072	SS	48	M	Ruptured ACOM aneurysm SAH,IVH hydrocephalus	14	17	2(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
42	1330280	DS	55	M	Ruptured ACOM aneurysm SAH,IVH hydrocephalus	9	27	3(1)	Yes (LRTI)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)			-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)			-	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
43	1335946	RS	56	M	Left supraclinoid ICA aneurysm	11	27	3(1)	-	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
44	1342863	Nk	50	M	Post. Fossa bleed,hydrocephalus	13	8	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
45	13347017	SS	65	M	Right thalamocapsular bleed Ivh Hydrocephalus	9	28	3(1)	Yes (LRTI)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
46	1346336	DS	32	M	multiple hemorrhagic contusions	3	9	1	tracheal culture positive	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
47	1353175	GK	52	F	Spontaneous Sah Ivh	8	17	2(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
48	1354437	SK	75	F	Left thalamic bleed with IVH	10	8	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
49	1355600	BS	53	M	SAH ,IVH	10	10	1	NO	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
50	1357274	KK	54	F	Traumatic SAH hydrocephalus	8	7	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
51	1327475	PK	34	M	IVH,Hydrocephalus	13	17	2(1)	NO	yes	yes	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
52	1358276	GS	40	M	Brain stem infarct with hydrocephalus	3	10	1	Yes (LRTI)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative

S. NO	MRD No.	Cytology								Biochemistry				CULTURE				Blood Sugar				Frequency of CSF sampling	Other neurosurgical procedure	Length of icu stay	Length of hospital stay	Complications	GOS at discharge
		At the time of insertion		4th day		7th day		10 th day		At the time of insertion	4th day	7th day	10 th day	At the time of insertion	4th day	7th day	10 th day	At the time of insertion	4th day	7th day	10 th day						
		TLc	RBC	TLc	RBC	TLC	RBC	TLC	RBC	Glucose	Glucose	Glucose	Glucose														
27	1292072	10	500	10	200	4	100	4	100	99	85	84	75	no growth	no growth	no growth	no growth	118	129	132	121	4	Yes	10	21	No	3
28	1298341	20	1000	10	1000	10	200	-	-	66	84	74	-	no growth	no growth	no growth	-	126	129	113	118	5	Yes	10	20	No	2
29	1298756	4	100	2	100	2	50	-	-	87	82	67	-	no growth	no growth	no growth	-	112	110	127	122	6	No	14	20	No	3
30	1292818	10	200	6	180	4	100	4	80	95	97	76	67	no growth	no growth	no growth	no growth	132	122	127	121	5	No	14	21	No	3
		2	50	2	20	-	-	-	-	88	84	-	-	no growth	no growth	-	-	119	114	121	118	-	-	-	-	-	-
31	1300245	10	4000	10	1000	10	1000	10	500	98	88	75	89	no growth	no growth	no growth	no growth	119	126	124	116	6	No	18	24	NO	4
		6	500	4	100	-	-	-	-	88	84	-	-	no growth	no growth	-	-	114	103	107	117	-	-	-	-	-	-
32	1297841	20	2000	10	1000	10	800	10	500	86	88	94	84	no growth	no growth	no growth	no growth	134	136	142	112	4	YEs	12	22	NO	5
33	1307244	10	1000	10	800	8	500	4	100	77	86	68	72	no growth	no growth	no growth	no growth	118	123	117	119	9	Yes	20	36	No	3
		4	100	2	100	2	150	2	100	82	98	66	69	no growth	no growth	no growth	no growth	106	128	108	126	-	-	-	-	-	-
		2	50	2	20	2	10	-	-	66	88	82	-	no growth	no growth	no growth	-	118	124	122	110	-	-	-	-	-	-
34	1311698	4	100	4	100	2	50	2	20	99	87	79	88	no growth	no growth	no growth	no growth	132	128	122	118	7	No	15	25	No	4
		2	100	-	-	-	-	-	-	86	88	-	-	no growth	-	-	-	-	-	-	-	-	-	-	-	-	-
35	1314054	2	0	5	100	19	30,000	5	4000	160	106	121	111	No growth	No growth	No growth	No growth	174	120	140	130	18	Yes	28	37	Yes(infection)	-
		2	4000	80	100	60	100	10	1000	100	1	20	30	No growth	No growth	No growth	No growth	126	126	138	122	-					2
		20	1000	10	50	5	30	4	20	36	54	78	64	No growth	No growth	No growth	No growth	118	124	120	114	-					
		2	100	2	80	-	-	-	-	92	89	-	-	No growth	No growth	No growth	No growth	122	134	132	126	-					
36	1133995	18	1000	10	500	4	200	3	100	82	88	84	93	No growth	No growth	No growth	No growth	129	132	125	115	4	No	10	20	No	3
37	1321132	16	2000	10	100	10	500	10	350	93	96	76	84	no growth	no growth	no growth	no growth	132	128	122	124	5	No	14	21	No	2
		10	250	4	100	-	-	-	-	86	87	76	88	No growth	No growth	No growth	No growth	127	126	121	112	-	-	-	-	-	-
38	1325919	4	0	2	0	2	0	2	0	93	92	87	76	no growth	no growth	no growth	no growth	128	118	109	112	4	NO	10	18	NO	3
39	1326746	10	2000	10	1000	10	700	5	500	78	77	86	68	no growth	no growth	no growth	no growth	106	128	108	126	6	Yes	15	22	No	2
		4	250	4	100	-	-	-	-	98	87	69	78	No growth	No growth	No growth	No growth	118	124	122	110	-	-	-	-	-	-
40	1124954	4	0	2	0	2	0	1	0	78	79	76	96	no growth	no growth	no growth	no growth	109	110	118	105	4	Yes	12	18	no	2
41	1329072	20	3000	10	2000	10	1000	10	1000	84	78	85	94	no growth	no growth	no growth	no growth	124	129	114	117	6	Yes	16	24	No	4
		7	500	5	500	4	250	-	-	87	76	97	-	no growth	no growth	no growth	-	130	127	124	14	-	-	-	-	-	-
42	1330280	10	1000	2	100	2	100	2	100	78	72	68	89	no growth	no growth	no growth	no growth	138	134	124	121	12	Yes	17	27	YES(infection)	3
		5	30	2	100	5	50	10	100	88	72	78	82	no growth	no growth	no growth	no growth	124	132	112	98						
		10	100	30	100	10	100	-	-	66	38	32	42	no growth	E.Coli growth	no growth	-	110	124	142	114						
43	1335946	10	1000	10	500	10	500	8	250	88	98	89	87	no growth	no growth	no growth	no growth	123	128	129	116	11	YEs	18	24	NO	3
		6	200	4	200	2	100	2	150	92	83	67	78	no growth	no growth	no growth	no growth	117	109	116	124	-	-	-	-	-	-
		2	100	2	50	2	50	-	-	88	82	93	-	no growth	no growth	no growth	-	112	118	119	-	-	-	-	-	-	-
44	1342863	5	100	4	100	2	50	-	NAD	92	89	83	-	no growth	no growth	no growth	-	118	115	126	108	3	No	10	17	No	4
45	13347017	10	3000	10	1000	10	1000	8	500	93	97	78	89	no growth	no growth	no growth	no growth	106	128	108	126	11	No	20	35	NO	3
		8	500	4	400	4	250	4	100	88	94	67	89	no growth	no growth	no growth	no growth	118	124	122	110	-	-	-	-	-	-
		4	50	2	50	2	20	-	-	82	98	87	-	no growth	no growth	no growth	-	118	115	112	-	-	-	-	-	-	-
46	1346336	4	100	2	100	2	20	-	NAD	92	89	78	-	no growth	no growth	no growth	no growth	124	118	114	119	3	No	13	24	No	2
47	1353175	10	2000	10	1000	10	1000	8	500	78	89	88	87	no growth	no growth	no growth	no growth	118	115	118	115	6	No	15	24	No	3
		6	500	4	250	2	200	-	-	88	78	92	95	no growth	no growth	no growth	-	108	110	122	109	-	-	-	-	-	-
48	1354437	10	1000	10	1000	5	500	-	-	96	92	87	-	no growth	no growth	no growth	no growth	106	128	108	126	3	No	10	18	no	3
49	1355600	10	1000	6	1000	5	500	5	250	78	85	82	91	no growth	no growth	no growth	no growth	118	124	122	110	4	No	7	15	NO	5
50	1357274	8	2000	6	1000	5	500	-	-	87	83	98	-	no growth	no growth	no growth	no growth	125	115	109	121	3	NO	8	20	NO	2
51	1327475	10	3000	10	2000	10	1000	10	500	78	87	69	89	no growth	no growth	no growth	no growth	121	116	108	114	6	NO	14	14	NO	4
		6	500	4	250	2	200	-	-	67	82	93	-	no growth	no growth	no growth	-	117	119	123	118	-	-	-	-	-	-
52	1358276	2	0	2	0	1	0	0	-	88	82	92	89	no growth	no growth	no growth	no growth	109	118	114	121	4	No	14	27	No	3

S. NO	MRD No.	Initial	Age	Sex	Diagnosis	GCS at admission	Duration of EVD	No. of EVD placed	Systemic coinfection	Antibiotic prophylaxis	Intraventricular Antibiotic used	Gram Stain				ZN stain				KOH stain			
												At insertion	4th day	7th day	10th day	At the time of insertion	4th day	7th day	10 th day	At the time of insertion	4th day	7th day	10 th day
53	1361577	TD	44	F	Planum Sphenoidal meningioma with hydrocephalus	10	14	2(1)	Yse (systemic candidiasis)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)			-	-	-	-	-	-	negative	-	-	-	-	-	-
54	1365312	H	54	F	Left cerebellar infarct with hydrocephalus	9	7	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
55	1363626	LS	42	M	Diffuse SAH with ruptured ACA aneuyrsm IVH hydrocephalus	11	8	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
56	1368424	SD	70 F	F	ACOM Aneurysm with SAH	10	25	3(1)	Yes (LRTI,Urosepsis)	yes	yes	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
57	1373975	JS	25	M	Ruptured ACOM aneurysm SAH,IVH hydrocephalus	10	15	2(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	-	-	-
58	1379290	JK	30	F	Brain stem infarct with hydrocephalus	8	25	3(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-	-
59	1398350	GS	60	M	Ruptured ACOM aneurysm SAH,IVH hydrocephalus	13	10	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
60	1386470	BS	45	M	Ruptured Aca aneurysm SAH IVH Hydrocephalus	10	15	2(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-	-
61	1398364	KS	52	m	Ruptured ACOM aneurysm SAH,IVH hydrocephalus	12	25	3(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-	-
62	1405268	HK	54	F	Right thalamic bleed,Rt MCA aneurysm IVH Hydrocephalus	9	18	2(1)	Yes (LRTI)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
63	1399481	IS	55	M	Posterior fossa bleed with hydrocephalus	10	24	3(1)	Yes (LRTI)	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(3)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-
64	1403030	AS	60	M	Left cerebellar bleed with hydrocephalus	13	10	1	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
65	1399093	AM	72	M	Right gangiocapsular bleed with IVH	9	15	2(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-	-
66	1403204	RS	65	M	Ruptured ACOM aneurysm SAH, hydrocephalus	11	16	2(1)	No	yes	no	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	negative
								(2)				negative	negative	negative	negative	negative	negative	negative	negative	negative	negative	-	-

S. NO	MRD No.	Cytology								Biochemistry				CULTURE				Blood Sugar				Frequency of CSF sampling	Other neurosurgical procedure	Length of icu stay	Length of hospital stay	Complications	GOS at discharge
		At the time of insertion		4th day		7th day		10 th day		At the time of insertion	4th day	7th day	10 th day	At the time of insertion	4th day	7th day	10 th day	At the time of insertion	4th day	7th day	10 th day						
		TLc	RBC	TLc	RBC	TLC	RBC	TLC	RBC	Glucose	Glucose	Glucose	Glucose														
53	1361577	2	5	50	1000	10	50	2	100	92	32	26	30	no growth	no growth	no growth	-	132	144	140	156	6	No	7	23	yes(infection, blockage)	3
		2	10	2	100	-	-	-	-	36	76	80	92	no growth	no growth	no growth	-	138	158	124	142	-	-	-	-	-	-
54	1365312	2	0	4	0	2	0	-	-	82	78	87	-	no growth	no growth	no growth	-	115	121	116	109	3	No	8	16	NO	3
55	1363626	10	2000	6	1000	4	1000	-	NAD	78	84	82	-	no growth	no growth	no growth	-	125	126	115	112	3	Yes	14	22	No	3
56	1368424	5	30	5	1000	2	100	2	100	122	110	116	98	no growth	no growth	no growth	no growth	180	164	166	168	10	-	-	-	yes(infection)	-
		10	1000	5	1000	20	100	30	1000	134	84	65	34	no growth	no growth	no growth	no growth	162	162	182	155		yes	15	28		3
		5	30	2	100	-	-	-	-	110	118	-	-	no growth	no growth	no growth	no growth	150	148	-	-			-	-		-
57	1373975	10	1000	10	500	10	500	5	100	83	64	78	77	no growth	no growth	no growth	no growth	119	124	127	112	5	Yes	15	23	No	4
		4	100	4	100	-	-	-	-	69	84	-	-	no growth	no growth	-	-	115	127	118	123	-	-	-	-	-	-
58	1379290	4	10	4	8	2	0	2	0	82	92	78	82	no growth	no growth	no growth	no growth	132	127	123	129	8	No	20	32	No	2
		2	0	0	0	2	2	0	0	77	72	93	73	no growth	no growth	no growth	no growth	117	119	128	122	-	-	-	-	-	-
		0	0	2	0	-	-	-	-	69	83	-	-	no growth	no growth	-	-	123	112	117	129	-	-	-	-	-	-
59	1398350	10	2000	10	1000	10	1000	4	250	78	85	95	84	no growth	no growth	no growth	no growth	124	122	117	121	4	Yes	10	16	NO	4
60	1386470	10	2000	10	1000	10	1000	10	500	75	88	85	74	no growth	no growth	no growth	no growth	123	116	128	110	5	Yes	14	21	No	3
		5	500	4	200	-	-	-	-	89	94	-	-	no growth	no growth	-	-	112	125	118	127	-	-	-	-	-	-
61	1398364	10	3000	10	2000	10	1000	6	1000	95	78	84	78	no growth	no growth	no growth	no growth	124	129	132	133	10	YEs	18	30	NO	3
		4	500	4	500	4	500	2	100	87	92	67	84	no growth	no growth	no growth	no growth	142	117	126	128	-	-	-	-	-	-
		2	100	2	100	-	-	-	-	99	95	-	-	no growth	no growth	-	-	122	128	119	116	-	-	-	-	-	-
62	1405268	10	1000	10	1000	4	1000	4	500	88	92	78	93	no growth	no growth	no growth	no growth	132	142	122	128	6	No	18	28	No	2
		6	500	4	250	2	200	-	-	87	83	82	-	no growth	no growth	no growth	-	128	119	121	-	-	-	-	-	-	-
63	1399481	4	50	4	20	2	10	2	10	78	77	92	89	no growth	no growth	no growth	no growth	`122	129	132	112	8	NO	20	30	no	5
		2	10	2	20	4	20	2	10	67	68	98	87	no growth	no growth	no growth	no growth	125	115	109	121	-	-	-	-	-	-
		2	4	2	2	-	-	-	-	82	86	-	-	no growth	no growth	-	-	127	119	112	116	-	-	-	-	-	-
64	1403030	4	100	4	100	2	50	2	20	89	82	87	78	no growth	no growth	no growth	no growth	106	128	108	126	4	-	10	16	No	5
65	1399093	20	1000	10	1000	10	1000	5	1000	78	67	83	87	no growth	no growth	no growth	no growth	122	129	115	115	5	NO	12	22	NO	3
		4	500	4	200	-	-	-	-	66	84	-	-	no growth	no growth	-	-	128	109	116	114	-	-	-	-	-	-
66	1403204	10	2000	10	1000	10	1000	5	1000	78	73	67	83	no growth	no growth	no growth	no growth	128	122	108	110	5	Yes	17	24	No	3
		4	500	4	200	-	-	-	-	87	84	-	-	no growth	no growth	no growth	no growth	110	122	126	114	-	-	-	-	-	-

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The Principal,
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Subject: **Approval of Plan of Thesis.**

This is to inform you that the Faculty of Medical Sciences in its meeting held on 29.10.2021 has approved the plan of thesis of **Ramandeep Singh Walia**, a student of your college for **MCh Neuro-Surgery** along with the names of Supervisor/Co-Supervisor as under:-

Topic Plan of Thesis
Study of risk factors and outcome in external ventricular drain infections.

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The student has to submit the four copies of thesis (along with PDF format) , to the Controller of Examinations, BFUHS, Faridkot, at least six months before the commencement of theory examination, if he/she is otherwise eligible to take the examination. He /She must directed to attach a photocopy of this letter with the forwarding letter while submitting thesis to the University along with the letter of approval of University for change of supervisor/Co-Supervisor, change of topic,(if any).

Dr. S P Singh MS(Oph)
Controller of Examinations

Note :

175. *If any discrepancy found regarding topic of thesis or Supervisor/Co-Supervisor, inform undersigned within one month after issue of this letter.*
176. *The student may submit the thesis as per the schedule already conveyed i.e for May/June examination 30th Nov of the preceding the year of examination and for Nov/Dec examinations 31st May of the year of examination.*

STUDY OF RISK FACTORS AND OUTCOME IN EXTERNAL VENTRICULAR DRAIN INFECTIONS

THESIS PROPOSAL

FOR APPROVAL OF SUBJECT OF THESIS TO BE SUBMITTED
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

M.Ch.
In
NEUROSURGERY

OF THE

BABA FARID UNIVERSITY OF HEALTH SCIENCES
FARIDKOT

AUGUST 2021

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ABSTRACT OF PLAN OF THESIS

Title	**STUDY OF RISK FACTORS AND OUTCOME IN EXTERNAL VENTRICULAR DRAIN INFECTIONS**
For the degree of	**M.Ch. Neurosurgery**
Name of the candidate	**Dr. Ramandeep Singh Walia**
Supervisor	**Dr. Ashwani K Chaudhary,** Professor and Head, Department of Neurosurgery, DMCH, Ludhiana
Co-supervisor	**Dr. Shivender Sobti,** Associate Professor, Department of Neurosurgery, DMCH, Ludhiana
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INTRODUCTION: External Ventricular Drains are used in neurosurgery to monitor intracranial pressure as well as a treatment of continuous raised intracranial pressure. However, it is associated with many complications and the most common complication is infection.

AIMS & OBJECTIVES: The study will be conducted to analyse the risk factors associated with external ventricular drain related infections and to assess the outcome in these patients.

MATERIAL & METHODS: The study will be conducted on patients who will undergo external ventricular drain placement in Department of Neurosurgery in Dayanand Medical College and Hospital from August 2021 to October 2022. The patients will have to satisfy the inclusion criteria and none of the exclusion criteria. The data collected will be compiled and analysed to study the incidence, risk factors and the outcome of the external ventricular drain infections. All statistical calculations will be done using (Statistical Package for the Social Science) SPSS 21 version (SPSS inc., Chicago IL, USA) statistical program for Microsoft windows.

CLINICAL SIGNIFICANCE: The knowledge of risk factors associated with External drain infections will help in reducing the incidence of infection and thus improving the outcome in these patients.

KEYWORDS: EXTERNAL VENTRICULAR DRAIN (EVD), INFECTION, RISK FACTORS

Candidate's sign Co-supervisor's sign Supervisor's sign Principal's sign

CERTIFICATE OF FACILITIES AVAILABLE

This is to certify that the facilities for work on the subject of thesis titled **"STUDY OF RISK FACTORS AND OUTCOME IN EXTERNAL VENTRICULAR DRAIN INFECTIONS"** exist in the Department of Neurosurgery, Dayanand Medical College, Ludhiana & will be provided to the candidate. We will see that the data being included in the thesis are genuine & is collected by the candidate himself under our supervision & guidance.

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PROFORMA FOR REGISTRATION OF SUBJECT FOR DISSERTATION

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5	TITLE OF THE TOPIC	**STUDY OF RISK FACTORS AND OUTCOME IN EXTERNAL VENTRICULAR DRAIN INFECTIONS**

6 BRIEF RESUME OF THE INTENDED WORK

6.1 NEED FOR THE STUDY

External Ventricular Drains are commonly used in neurosurgery to monitor intracranial pressure as well as a treatment of continuous raised intracranial pressure. The placement of external ventricular drain is an invasive procedure and is associated with many complications e.g Hemorrhage, blockage, dislodgement, misplacement and the most common complication is infection. The external ventricular drain is a foreign body inserted in to the brain and is therefore, a potential portal for infections. The rate of infection in external ventricular drains ranges from <5% to 23% with the average close to 10%.[1] The infection increases the stay of patients in hospitals and their morbidity. Skull fracture with leakage of cerebrospinal fluid, Subarachnoid hemorrhage, craniotomy, Intraventricular hemorrhage, irrigation of External ventricular drainage devices and simultaneous systemic infections, extended EVD dwell time, frequency of cerebrospinal fluid sampling, frequency of EVD manipulation, number of EVD insertions, tract hemorrhage at placement, length of duration of catheterization, insufficient hair clipping are the various risk factors for the external ventricular drainage devices infections.[1-6]

Bacteria can be introduced in ventricles either during the surgery, from the distal end of the drain retrogradely or during manipulations of the drain which is done routinely.[7] The most common route is the retrograde transfer from the distal end of the drain. [8]

To diagnose ventricular related infections is also difficult especially in patients with blood mixed in cerebrospinal fluid or in any neurological condition obscuring infection related characteristics of cerebrospinal fluid. Sometimes sterile inflammatory response to neurosurgical intervention can also lead to difficulty in diagnosing external ventricular drain related infections.[9] These diagnostic difficulties can lead to delay in treatment of patients.[10,11]

According to the Center for Diseases Control and Prevention, the criteria for ventriculitis or meningitis diagnosis are as follow: (1) positive CSF culture results plus clinical symptoms or CNS pleocytosis/cell count increase; or (2) in the case of negative CSF culture, clinical symptoms and increased pleocytosis of the central nervous system (CNS), increased serial measurement/cell count, hypoglycemia (less than50% of simultaneous blood sugar), and increased lactate (more than 2 mmol/dL or 36 mg/lit) or gram-positive smear.[12] Thus, whenever a external ventricular drain infection is suspected , a sample of CSF is taken from drain and is sent for gram staining, Potassium hydroxide (KOH) stain, Ziehl Neelsen(ZN) staining, culture, concentration of glucose and ratio, leukocyte count and differentiation and total protein concentration. [12-14]

Incomplete knowledge of factors which lead to external ventricular drain infections has led to poorly standardised EVD prevention strategies. In the last 20 years, the focus is on improving the accuracy of access to the ventricles, control of infections and the safety of procedure. Thus, the study will be conducted to have better knowledge of various risk factors of external ventricular drainage devices related infections and their outcomes so that preventive measures can be taken to prevent this complication.

6.2 REVIEW OF LITERATURE

The first External Ventricular Drain was invented by the French surgeon Claude Nicolas Le Cat in 1744. He introduced a specially invented cannula in a newborn child for the treatment of congenital hydrocephalus.[15] Further major advancement was made by the Nils Lundberg in 1960 when analysis of monitoring of intracranial pressure was published in brain tumor patients. This lead to the use of External Ventricualr Drain in patients with subarachnoid hemorrhage, brain trauma, Reye syndrome. [16]

In a study conducted in Brazil to study the incidence rates and risk factors predisposing to external ventricular drain related infections , a total of 119 patients ,130 external ventricular device procedures and 839 catheter days were evaluated. The infection incidence was found to be 18.3%, 16.9% per procedure was the infection rate and the drain associated infection rate was 22.4 per 1,000 catheter days. 77% of infection were caused by Gram negative organisms. 75% patients received antibiotic prophylaxis. The rate of infection increases with the longer hospital stay of the patients. The duration of time catheter was in place was found to be independent risk factor associated with infection. [2]

In another retrospective study conducted on 343 patients who underwent External Ventricular drain placement, 12 patients acquired infection. No significant difference was found in patients with or without ventriculitis for age, sex, systemic infection and underlying systemic infections. Concomitant systemic infections was seen in 4.7% of patients with External ventricular drain related infections compared to 1.5 % patients without external ventricular drain related infections. The difference in length of EVD placement in patients with ventriculitis was 20.9 ± 15.3 days and 12.1 ± 18.2; P = 0.005 in patients without ventriculitis and difference was found to be significant. The most commonly associated pathogens were Coagulase-negative Staphylococcus and Staphylococcus aureus.[3]

In a prospective epidemiological study to study the incidence, risk factors and clinical characteristics of ventriculostomy related infections on 172 patients over 2 years period, Ventriculitis occurred in 19 patients (11%) out of 172 . Cerebrospinal-fluid pleocytosis was more significantly associated with the diagnosis of ventriculitis or meningitis (P less than 0.0001) than were fever and leukocytosis (P = 0.07). Risk factors for ventriculitis were found to be intracerebral hemorrhage with intraventricular hemorrhage (P= 0.027), neurosurgical operations (P = 0.016), intracranial pressure of 20 mm Hg or more (P = 0.019), ventricular catheterization for more than five days (P = 0.017), and irrigation of the system (P = 0.021). No increased risk of infection was found on subsequent procedures in patients with previous ventriculostomy in this study.The study concluded that ventriculitis may be prevented by maintaining closed drainage system and by early removal of the ventricular catheter. The catheter should be removed and inserted at a different site if monitoring is required for more than 5 days.[4]

In a study conducted on 78 patients to study the rate of bacterial ventriculitis in relation to duration of catheter insertion and the factors which contribute to drain infections, it was found that higher rate of ventriculitis was found in patients with mean catheter duration of 11 days or more than that. It was also found the the group which developed the ventriculitis showed increase in cerebrospinal fluid lactate levels prior to the onset of ventriculitis.[12]

In a prospective surveillance study conducted to determine drain associated infection rates and Drainage Days(DD) of hospital acquired external ventricular drain (EVD) and lumbar drain (LD) associated meningitis/ventriculitis in a neurosurgery and a neurological intensive care unit,1333 patients were included, amounting to 3023 DD. 26 cases of meningitis were reported after excluding 15 cases of contamination, accounting for an overall device associated meningitis rate of 8.6 infections/1000 DD. Infections associated with Lumbar Drain seemed to occur more frequently (19.9/1000 DD) compared with EVD

(6.3/1000 DD). The presence of intraventricular blood and previous trauma were significant risk factors for infection (p=0.003; p=0.04). The length of stay was significantly longer in meningitis patients (p=0.0003). Coagulase negative staphylococci were the main pathogen (56%) causing meningitis, followed by Staphylococcus aureus (25%).[13]

In another study conducted on 228 patients from January 1993 to April 2005, the most common indication for External ventricular drain placement was hydrocephalus due to intraventricular haemorrhage (48.2%). Ventriculitis occurred in 23.2% of all patients. The duration of EVD drainage was found to be a risk factor for infection (>11 days: OR 4.1; 95% CI 1.8-9.2, p = 0.001). Another risk factor was the frequency of CSF sampling (no sampling: OR 0.2, 95% CI 0.2-0.5, p = 0.003). [17]

Another study conducted to analyse external ventricular drainage related ventriculits, 174 EVD catheters were introduced in 112 patients. 15 patients developed ventriculitis presenting infection incidence rate of 13.39% per patient and 8.62% per procedure. Out of 15 patients, 5 patients died from sepsis, 7 patients recovered from infections but some neurological complications were seen and 3 patients recovered without any complications. The most common pathogen found in this study was Acinetobactoer baumanii. The prior clinical diagnosis showed the statistical significance as a risk factor. Higher incidence of infection was seen in patients with severe head trauma because of contaminative environment. [18]

In a study conducted on 84 patients to study the incidence and risk factors of ventriculostomy associated infections, 99 catheters were placed, of which 19% developed VAI. There was a total of 586 catheter days (infection rate, 32 per 1000 catheter days). The risk of VAI increased steadily until catheter day 7 then reached a plateau. There were no significant associations with age, severity of illness, indication for the catheter, craniotomy, or presence of CSF leak. The number of catheter days and repeat catheter insertion emerged as significant independent risk factors for ventriculostomy infections. Placement outside the operating room was associated with a trend toward higher

VAI. The use of prophylactic antibiotic or antibiotic irrigation did not significantly alter VAI rates. Routine surveillance cultures of CSF were no more likely to detect infection than cultures obtained when clinically indicated. Gram-negative bacilli were responsible for 50% of the infections, followed by gram-positive cocci (29%) and others (21%).[19]

In a retrospective study conducted on 199 patients to evaluate the relationship among duration and revision of external ventricular drain and cerebrospinal fluid infections, 269 external ventricular drain were inserted at a major trauma centre in Australasia. Out of total 21 cerebrospinal fluid infections, 10 (48%) were found to be caused by Acinetobacter. Multiple insertions of external ventricular drains was found to be a significant risk factor. In previously uninfected patients second and third external ventricular drain was found to be more likely associated with the infection rate. The mean period of external ventricular drain was found to be 5.5$\pm$0.7 days postinsertion.[20]

In a retrospective single centre study conducted on 218 patients with 246 EVD placement over a 30 month period to evaluate the incidence of external ventricular drain related infections and to identify the underlying risk factors, the cumulative incidence of infection was found to be 8.3%(95% CI, 5.3-12.7) with device associated infection rate of 10.4 per 1000 drainage days(95%CI, 6.2-16.5). Patients with EVD related infection had a longer stay in intensive care unit (11 versus 21 days,P <0.01) and in hospitals(20 versus 28.5 days, P<0.01) than patient without infections. The mean total duration of external ventricular drain was twice longer in patients with external ventricular drain related infections(6 versus 12 days, P<0.01). The most common pathogen found was coagulase negative Staphylococcus(62%) followed by Enterococcus spp(19%). There was no significant difference in the duration of first External ventricular drain placement and the occurrence of infection and external ventricular drain removal in patients without ventriculitis (6 versus 7 days, P=0.87) respectively.[21]

In a retrospective study conducted at Aga khan university hospital to study outcome of external ventricular drain infections and

predictors of unfavourable outcome, 256 patients were included. 66 patients (25.8%) developed VAI. EVD was the primary procedure in 21 (31.8%) cases. 24 (36.4%), had EVD as a secondary procedure for tumor surgery. Median interval between EVD placement and diagnosis of infection was 3 days. Mean length of stay in VAI patients was 31.85 ± 20.53 days. Seven patients required ICU care. Ten patients (15.2%) expired during hospital stay or within 30 days of discharge and further four had GOS of 2 or 3. A total of 52 patients had a favorable outcome after 6 months.The study concluded that ventriculostomy infections were associated with increased morbidity, increased mortality and prolonged hospital stay.[22]

In another study conducted on 58 patients undergoing External ventricular drain insertion in the Intensive Care Unit (ICU) in Neurosurgery Department of Xuanwu Hospital of Capital Medical University between January 1 and December 31, 2015, the infection rate was calculated as 8.6% (10.9/1000 EVD days). The duration of EVD (≥11 d, Wals=4.8, RR=17.3, 95% CI: 1.4-218.3, P=0.028), CSF sampling frequency (≤2 d, Wals=5.3, RR=15.3, 95% CI: 1.5-243.7, P=0.022), and concomitant pulmonary infection (RR=7.8, 95% CI: 0.8-74.8, P=0.04) were found to be the risk factors of EVD-related infections.[23]

In a prospective multicentre cohort study to study the infection rate and risk factors for external ventricular drain infections in 21 neurosurgical units over 6 months, a total of 495 EVD catheters were inserted into 452 patients with EVDs remaining in situ for 4700 days (median 8 days; IQR 4–13). Of the catheters inserted, 188 (38%) were antibiotic-impregnated, 161 (32.5%) were plain and 146 (29.5%) were silver-bearing. A total of 46 external ventricular infections occurred giving an infection risk of 9.3%. Cox regression analysis demonstrated that factors independently associated with increased infection risk included duration of EVD placement for ≥8 days (HR=2.47 (1.12–5.45); p=0.03), regular sampling (daily sampling (HR=4.73 (1.28–17.42), p=0.02) and alternate day sampling (HR=5.28 (2.25–12.38); p<0.01). The study concluded that External Ventricular Drains left in situ for ≥8

days and frequent sampling of cerebrospinal fluid were associated with a higher risk of infection. [24]

6.3 AIMS AND OBJECTIVES OF THE STUDY

1. To analyse the risk factors associated with external ventricular drain related infections.
2. To assess the outcome in patients of external ventricular drain related infections.

7.0 MATERIALS AND METHODS

7.1 SOURCE OF DATA

The study will be conducted on patients who will undergo external ventricular drain placement in Departrment of Neurosurgery in Dayanand Medical College and Hospital, Ludhiana from August 2021 to October 2022.

7.2 METHODS OF COLLECTION OF DATA

Inclusion criteria

1. All the patients above the age of 18 years who will undergo EVD placement.

Exclusion criteria

1.Patients with previous history of Central nervous system infections.

2.Patients presenting with open skull fracture.

3.Patients presenting with Cerebrospinal fluid leakage.

The data will be collected according to the demography, clinical diagnosis of the patient, previous medical history of any disease, previous history of placement of external ventricular drain, duration of EVD (in days), total number of EVD per person, frequency of cerebrospinal fluid sampling, microbiological result and the clinical outcome.

OPERATIVE PROCEDURE

The SURGIWEAR external ventricular drain will be used in the study and it will be inserted under sterile conditions in the operation theatre. The patient's scalp will be shaved and prepared with standard sterile technique. The skin incision will be given at kocher's point and catheter will be inserted in to the frontal horn of the ventricle for about 5 cm until cerebrospinal fluid is obtained. The catheter will be then tunneled under scalp laterally for about 5cm and will be connected using 3 way stopcocks to external cerebrospinal drainage system. The catheter will be securely fixed with suture and sterile dressing will be applied.

Prophylactics antibiotics will be administered before catheter insertion and during the period of drain in place.

All the patients will be monitored in intensive care unit and dressing will be done daily. The elevation of catheter will be forbidden to prevent back flow of cerebrospinal fluid.

The sample of cerebrospinal fluid will be taken at the time of external ventricular drain insertion and on 4^{th} day,7^{th} day, 10^{th} day or when patient develop signs of sepsis. The cerebrospinal fluid will be sent for cytology, biochemistry study, gram staining, KOH stain, ZN staining and culture. The blood sample will also be taken at the time of cerebrospinal fluid sampling for monitoring blood glucose levels.

If a patient will be found to have external ventricular drain related infection, then more detailed findings will be taken with regard to the possible factor leading to infection, antimicrobial susceptibility, treatment provided and the outcome of the patient.

If a patient require external drain insertion for extended duration then a new external drain will be inserted at another site at 10^{th} day.

If the cerebrospinal fluid culture study shows positive result, the antibiotic therapy will be started based on culture studies.

Outcome

Morbidity of the patients will be assessed and the patients will be grouped as good recovery, moderate disability,severe disability and vegetative state, death on the basis of criteria laid down by Glasgow Outcome Scale.

Statistical Analysis

Data will be described in terms of range; mean + standard deviation (+SD), median, frequencies (number of cases) and relative frequencies (percentages) as appropriate. The data collected will be compiled and analysed to study the incidence, risk factors and the outcome of the external ventricular drain infections. All statistical calculations will be

done using (Statistical Package for the Social Science) SPSS 21 version (SPSS inc., Chicago IL, USA) statistical program for Microsoft windows.

7.3 DOES THE STUDY REQUIRE ANY INVESTIGATIONS OR INTERVENTIONS TO BE CONDUCTED ON PATIENTS OR OTHER HUMANS OR ANIMALS? IF SO, PLEASE DESCRIBE BRIEFLY.

Yes, Routine investigations, cytology, biochemistry study, gram staining, KOH stain, ZN staining and culture of CSF, NCCT head.

7.4 HAS ETHICAL CLEARANCE BEEN OBTAINED FROM YOUR INSTITUTION IN CASE OF 7.3?

Attached Herewith

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PROFORMA S. No.

A) History

1. Name:
2. Age and Sex:
3. MRD NO:
4. Occupation:
5. Address:
6. Chief complaints:
7. Medical History:

B) Examination

1. Systemic Examination
2. Neurological Examination:

Glasgow Coma Scale(at the time of admission):

1. Diagnosis:
2. Treatment:
3. Date of EVD insertion:
4. Place of EVD insertion:
5. Date of change of EVD:
6. Duration of EVD:
7. Total number of EVD placed:
8. Antibiotic prophylaxis used:
9. Intraventricular antibiotic Instilled:
10. Cerebrospinal fluid Study

Signature of Candidate **Signature of Supervisor**

CSF examination	At the time of insertion of EVD insertion	Post EVD insertion		
		4th day	7th day	10th day
Gram Stain				
ZN stain				
KOH stain				
Cytology				
Biochemistry				
Culture				

11. Blood sugar:

	At the time of insertion of EVD insertion	Post EVD insertion		
		4th day	7th day	10th day
Blood sugar				

Signature of Candidate

Signature of Supervisor

12. Any systemic co infection:

13. Frequency of CSF sampling:

14. Other Neurosurgical operation done:

15. Treatment given:

16. Duration of hospital course:

    length of ICU stay:

    length of hospital stay:

17. Complications:

    a. Infection

    b. Hemorrhage

       Intraventricular hemorrhage

       Cortical hemorrhage

    c. Blockage

    d. EVD pulled out accidentally

    e. Wound infection

18. Outcome:

Glasgow Outcome scale at the time of discharge:

Signature of Candidate

Signature of Supervisor

INFORMED PATIENT CONSENT

Date: _____

I.....D/o, W/o, S/o..... am willing to participate in the study **"STUDY OF RISK FACTORS AND OUTCOME IN EXTERNAL VENTRICULAR DRAIN INFECTIONS"** The procedure with its complications has been explained to me in local vernacular language. I have fully understood that no special tests and extra expenditure in any form, merely for the purpose of thesis is being carried out. I am free to opt out of the study any time without assigning any reason.

....

Signature of the Witness Signature of the patient

Name:

Signature of Candidate **Signature of Supervisor**

मरीज अनुमति फार्म

तिथि_____

मैं_____ पत्नी/पुत्र/पुत्री_____

निवासी_____ इस शोधकार्य **"STUDY OF RISK FACTORS AND OUTCOME IN EXTERNAL VENTRICULAR DRAIN INFECTIONS"** में भाग लेने के लिए सहमत हूँ। मैं इस शोधकार्य में भाग लेने के लिए अपनी स्वेच्छा से तैयार हूँ। मैं पुष्टि करता/करती हूँ की यह स्वीकृति देने के लिए मुझे कोई आर्थिक प्रलोभन नहीं दिया गया और नही दबाव डाला गया है। मुझे इस शोधकार्य का उद्देश्य स्पष्ट कर दिया गया है और मुझे यह विश्वास है की यह विज्ञान और मानवता के लाभ के लिए है। मुझे इस शोधकार्य में होने वाले जोखिम के बारे में समझा दिया गया है और मेरी समझ में यह जोखिम बहुत मामुली है।

मैं इस शोधकार्य में भाग लेने के सम्बन्ध में किसी भी समय अपनी अस्वीकृतिव्यक्त कर सकता/सकती हूँ और मेरे अस्वीकृतिव्यक्त करने का मेरे इलाज पर कोई प्रभाव नहीं पड़ेगा।

_____ _____

गवाह के हस्ताक्षर रोगी के हस्ताक्षर/अंगूठे का निशान

नाम: नाम:

_____

अन्वेषक के हस्ताक्षर

_____

विद्यार्थी के हस्ताक्षर

ਮਰੀਜ਼ ਰਜ਼ਾਮੰਦੀ ਫਾਰਮ

ਮਿਤੀ_____

ਮੈ_____ਪਤਨੀ/ਪੁੱਤਰ/ਪੁੱਤਰੀ_____

ਵਾਸੀ_____"STUDY OF RISK FACTORS AND OUTCOME IN EXTERNAL VENTRICULAR DRAIN INFECTIONS" ਤੇਚਲ ਰਹੀ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਰਜ਼ਾਮੰਦ ਹਾਂ। ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਮੈ ਆਪਣੀ ਮਰਜ਼ੀ ਨਾਲ ਤਿਆਰ ਹਾਂ। ਮੈ ਇਹ ਦਸਣਾ ਚਾਹੁੰਦਾ ਹਾਂ/ ਚਾਹੁੰਦੀ ਹਾਂਕੇ ਇਹ ਰਜ਼ਾਮੰਦੀ ਦੇਣ ਵਾਸਤੇ ਮੈਨੂ ਕਿਸੇ ਵੀਤਰਾਂ ਦਾ ਲੋਭ-ਲਾਲਚ ਨਹੀ ਦਿੱਤਾ ਗਿਆ ਅਤੇ ਨਾਹੀ ਕੋਈ ਦਬਾ ਪਾਇਆ ਗਿਆ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਦਾ ਮਨੋਰਥ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਭਰੋਸਾ ਦਵਾਇਆ ਗਿਆ ਹੈਕੇ ਇਹ ਖੋਜ ਵਿਗਿਆਨ ਅਤੇ ਮਾਨਵਤਾਦੀ ਭਲਾਈ ਲਈ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਵਿਚ ਹੋਣ ਵਾਲੇ ਖਤਰੇ ਬਾਰੇ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹਯਕੀਨ ਹੈ ਕੇ ਇਹ ਖਤਰਾ ਬਹੁਤ ਮਾਮੂਲੀ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਦਾ ਢੰਗ – ਤਰੀਕਾ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ।

ਮੈ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਬਾਰੇ ਆਪਣੀ ਰਜ਼ਾਮੰ ਦੀ ਕਿਸੇ ਵੀ ਸਮੇ ਵਾਪਸ ਲੈ ਸਕਦਾ ਹਾਂ/ ਸਕਦੀ ਹਾਂ ਅਤੇ ਮੇਰੀ ਰਜ਼ਾਮੰਦੀ ਵਾਪਸ ਲੈਣ ਦਾ ਮੇਰੇ ਇਲਾਜ ਤੇ ਕੋਈ ਅਸਰ ਨਹੀ ਹੋਵੇਗਾ।

_____ _____

ਗਵਾਹ ਦੇ ਹਸਤਾਖਰ ਮਰੀਜ਼ ਦੇ ਹਸਤਾਖਰ

ਮਿਤੀ_____ ਮਿਤੀ_____

ਪਤਾ_____ ਪਤਾ_____

_____

ਨਿਰੀਖਕ ਦੇ ਹਸਤਾਖਰ

_____

ਸਿਖਿਆਰਥੀ ਦੇ ਹਸਤਾਖਰ